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CASCADE CREEK HYDROPOWER PROJECT

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

CASCADE CREEK HYDROPOWER PROJECT

Prepared by

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Hydrodynamics
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Montana Department of Natural Resources and Conservation
1520 East 6th Avenue, Helena, Montana 59620
Renewable Energy and Conservation Program
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Montana State Library, 1515 East Sixth Avenue
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General Description: This 65 KW capacity hydroelectric installation is designed to feed directly into the Park Electric Co-operative, Inc. power grid. The project is located totally within private land owned by Thomas K. and Jody L. Budde.

The system water intake, 860 feet above the powerhouse on Cascade Creek, is a concrete structure with trash screening, shut-off valve, and an air escape and vacuum inlet for the pipeline. The 6 inch pipeline is over ground aluminum for a short distance at the top, then buried PVC graduating in pressure rating to fiberglass reinforced PVC and then to steel inside the powerhouse. Total pipe length is 6,180 feet.

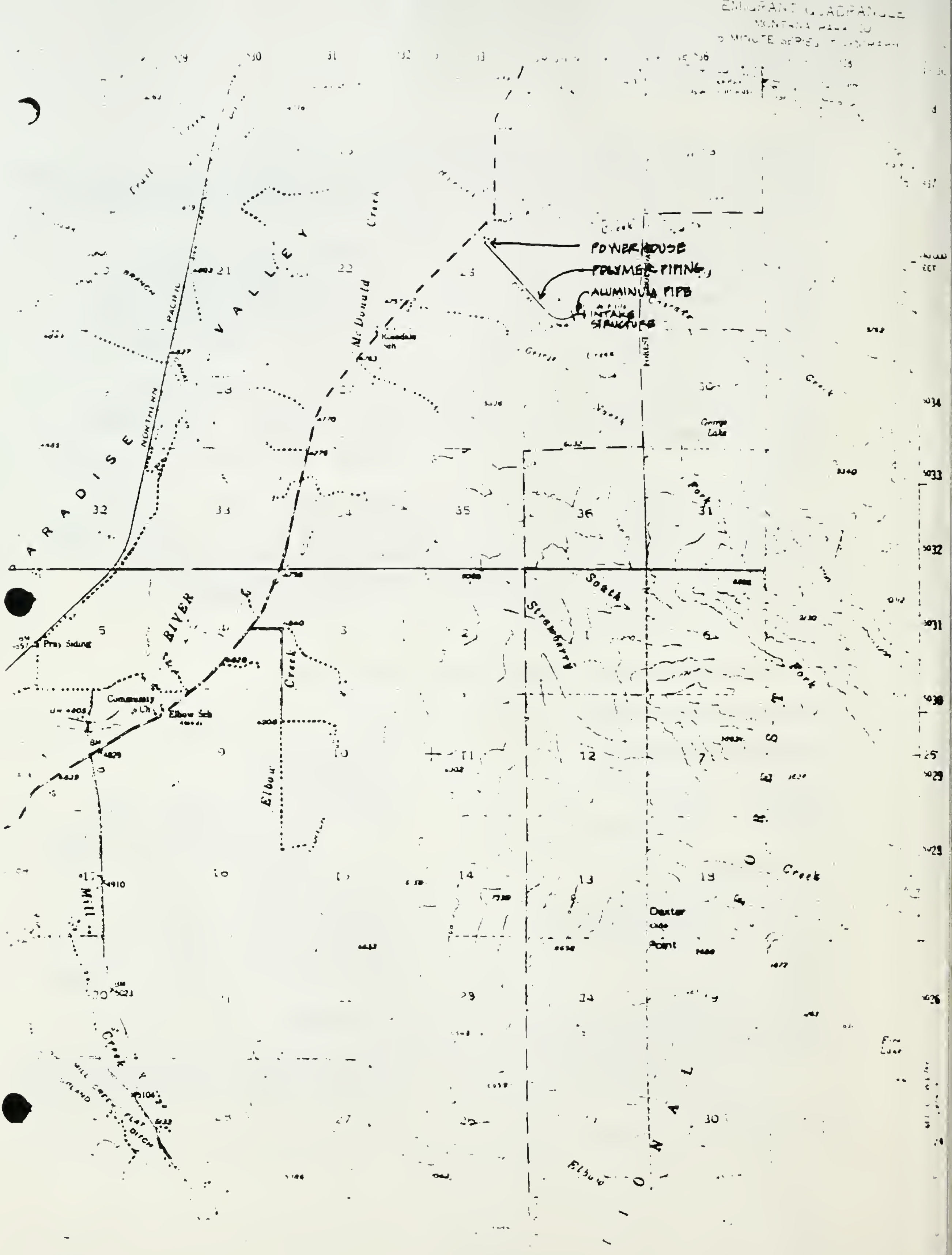
The steel piping (including a gate shut-off valve and a gate by-pass valve) at the powerhouse terminates at a hand operated needle nozzle of the pelton turbine assembly. The needle nozzle is adjusted throughout the year to follow available stream flow. A culvert discharges exhaust water back to Cascade Creek.

The horizontal shaft, overhung pelton-type turbine assembly is directly coupled to a 65 KW induction generator. Runaway and shutdown automatic protection is provided by a jet deflector which is solenoid actuated by an open condition of the main contactor.

The generator is interfaced to the grid transformer with switchgear, capacitive power factor correction, metering, and a lockable disconnect switch.

The table below gives the necessary statistics:

Diversion Structure:	Powerplant:
Height: 4 ft. Length: 20 ft. Material: Reinforced concrete	Rating: 1 unit @ 65 KW Manufacture: Small Hydroelectric Systems & Equipment pelton-type impulse turbine Static Head: 860 ft. Design Head: 782 ft. Hydraulic Capacity: 1.5 CFS Plant Factor: 60% Annual Output: 361,500 KWH *
Impoundment:	
Storage: Negligible Capacity: About 760 ft^3.	
Pipeline:	Customer:
Length: 6,180 ft. Dimension: 6 in. diameter Materials: Aluminum, PVC, reinforced fiberglass & steel	Power output is wheeled through Park Electric Co-operative, Inc. to the Montana Power Company.


POWERHOUSE
POLYMER PIPING
ALUMINUM PIPE
INTAKE STRUCTURE
PARADISE
VALLEY
NORTHERN
PACIFIC
BRANCH
RIVER
McDonald
Creek
Elbow
Creek
Mill
Creek
Pray Siding
Community Ch.
Elbow Sch.
George Lake
South
Strawberry
Fork
Dexter
Point
Trail

I. Preconstruction Phase

A. Preliminary Design

1. Flow rates were measured in 1981 at mid-month for months marked with an asterisk. Flow rate was determined by measuring the filling time of a container of known size at the diversion site. The rest of year flow rate was estimated by graphically comparing this flow data on other * local small streams. See enclosed graph.

   The resulting extrapolation is expected to be conservative since Cascade Creek is smaller than any of the streams to which it was compared. Smaller streams normally have larger swings from low flow to high flow. Spring and summer site flow estimates have substantiated this. For the purpose of power generation sizing, the low flow months are the most important. For this site, high flow months are only important in that they are greater than or equal to 1.5 CFS - maximum hydro intake. Also less water is taken for the hydroelectric system in the estimation of monthly kW and kWhr output than appears to be available. At these conservative estimates, plant capacity factor is about 60%.

Cascade Creek Flow Rates:

	JAN*	FEB*	MAR*	APR	MAY	JUN	JUL	AUG*	SEP*	OCT*	NOV*	DEC*
FLOW (CFS)	.60	.55	.50	5.00	10.00	7.50	2.30	1.70	1.20	.90	.80	.70

* Middle of Month Measurements

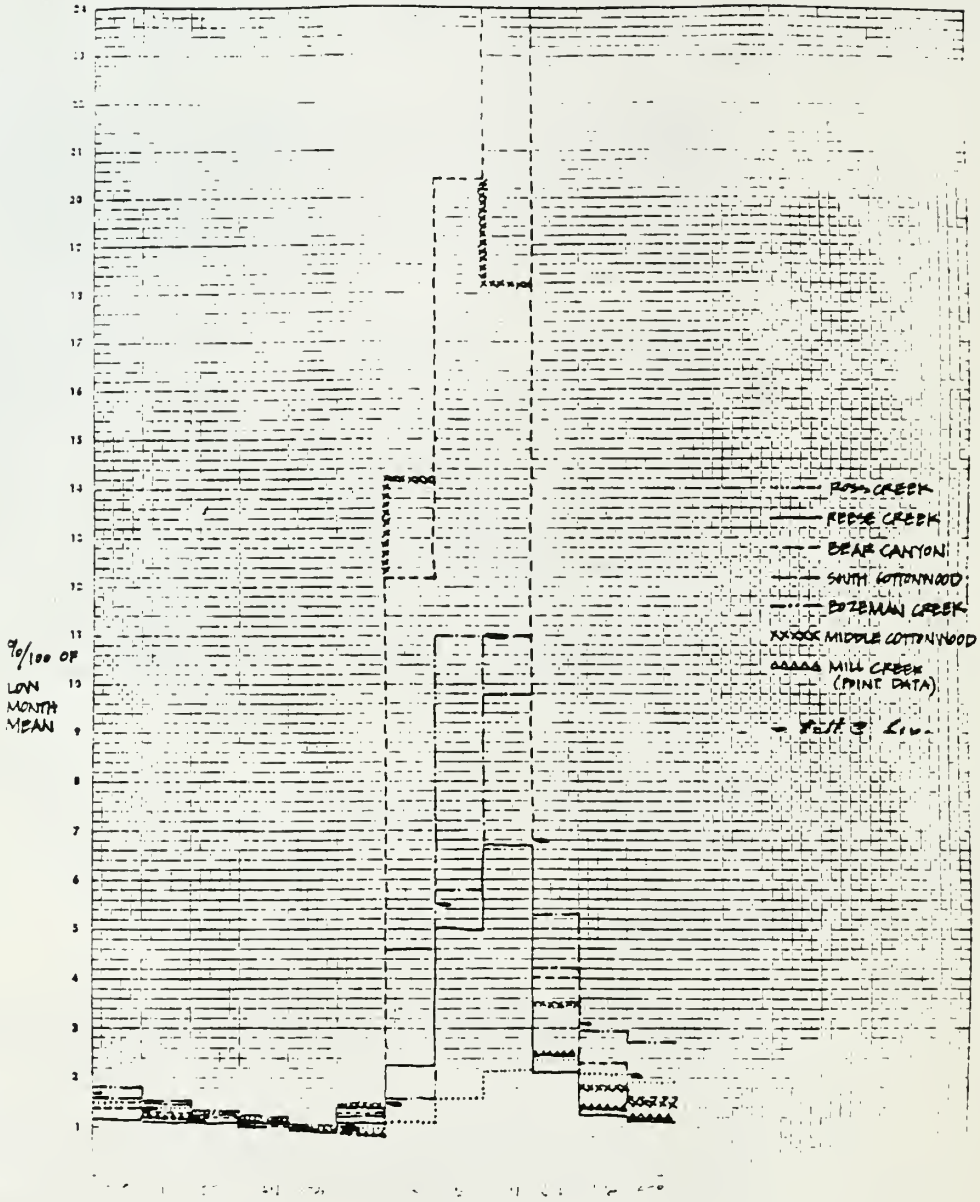
2. Head was determined for preliminary purposes using a topographical map. A surveying altimeter was used to determine head for final design purposes.

3. This design was arrived at using an iterative process of optimization that was influenced by many factors - the main ones being physical and environmental characteristics, economics, finance, land ownership, legislation and equipment reliability records.

4. This project's environmental concerns did not include dewatering a stream because the intake structure captures stream water just before it goes over a waterfall and totally becomes ground water. This lost water has now

APPENDIX D

AVERAGE MONTHLY FLOW RATES



become available to irrigate land below the powerhouse. The pipeline was routed over stable soils so that few trees had to be cut. Its installation was carried out carefully to minimize heavy equipment impact, and the backfill reseeded with native grasses so it will recover totally in a few years.

The diversion structure is a stable structure constructed over a short period of time, during low water in the Fall. Hand labor was used a lot to minimize the need for heavy equipment excavation and siltation. Except for the diversion, the entire installation is well above the 100 year flood plain level. All water is returned to the streambed at or below the natural stream velocity with its quality unchanged. See permit section for more information.

B. Permits

Because this plant is connected with a utility grid, a license or exemption from licensing was required by the Federal Energy Regulatory Commission (FERC). The FERC blue book is the best source of exemption application details. The following list of agencies were given a project description as a requirement of the FERC prelicensing process. Park County Conservation District inspected the site and issued a 310 permit for diversion construction. The Montana Historical Society required an archeological field survey, which found no historical resources. An application for non-consumptive water use was submitted to and received from the Montana DNRC Water Rights Bureau. All other agencies either gave their go-ahead or did not respond at all.

AGENCY	ACTION TAKEN
1. REGIONAL DIRECTOR, REGION 6 U.S. FISH & WILDLIFE SERVICE DENVER FEDERAL CENTER P.O. BOX 25486 DENVER, CO 80225	BILLINGS OFFICE CALLED ME & FOUND NO IMPACT STATUS FOR THE PROJECT
2. REGIONAL ENVIRONMENTAL OFFICER DEPT. OF THE INTERIOR BUILDING 67, ROOM 688 DENVER FEDERAL CENTER DENVER, CO 80225	THE U.S. DEPT. OF INTERIOR, OFFICE OF THE SECRETARY, OFFICE OF ENV. PROJECT REVIEW FORWARDED MY LETTER TO THE FOLLOWING AGENCIES: 1) FISH & WILDLIFE SERVICE, DENVER 2) NATIONAL PARK SERVICE, DENVER 3) GEOLOGICAL SURVEY, RESTON 4) BUREAU OF MINES, SPOKANE 5) BUREAU OF LAND MGMNT, BILLINGS 6) BUREAU OF RECLAMATION, BILLINGS NO FURTHER RESPONSE WAS NECESSARY ON MY PART
3. REGIONAL DIRECTOR HERITAGE CONSERVATION & RECREATION SERVICE DENVER FEDERAL CENTER, BUILDING 41 P.O. BOX 25387 DENVER, CO 80225	
4. REGIONAL ADMINISTRATOR, REGION VIII ENVIRONMENTAL PROTECTION AGENCY LINCOLN TOWER BUILDING, ROOM 900 1860 LINCOLN ST. DENVER, CO 80203	
5. CHAIRMAN, MISSOURI RIVER BASIN COMMISSION SUITE 403 10050 REGENCY CIRCLE OMAHA, NE 68114	MISSOURI RIVER BASIN COMMISSION WAS TERMINATED BY EXECUTIVE ORDER OF PRESIDENT REAGAN EFFECTIVE 9/30/81 & IS NO LONGER PART OF THE FERC LICENSING PROCESS.
6. DIRECTOR, NORTH WEST REGION NATIONAL MARINE FISHERIES SERVICE, NOAA 1700 WESTLAKE AVENUE, NORTH SEATTLE, WA 98109	NO IMPACT BY OUR PROJECT
7. DISTRICT ENGINEER U.S. ARMY ENGINEER DISTRICT 6014 USPO & COURTHOUSE 215 NORTH 17TH ST OMAHA, NE 68102	REQUIRED A SECOND COMMUNICATION REQUESTING A "SECTION 404" PERMIT STATUS. DISTRICT ENGINEER FOUND NO IMPACT & THEREFORE NO "404" PERMIT NECESSARY.

AGENCY	CONTACT PERSON	ACTION TAKEN
1. MONTANA PUBLIC SERVICE COMMISSION [redacted]27 - 11TH AVE. HELENA, MT 59620 449-3456	TED OTIS	NONE - P.S.C. CONTROL ONLY THOSE PROJECTS INVOLVING MONTANA POWER COMPANY
2. MONTANA DEPT. OF FISH, WILDLIFE, & PARKS 1420 EAST 6TH ST HELENA, MT 59620 449-2535	JIM POSEWITZ	NONE - PROJECT IS LOCATED ON FISHLESS CREEK
3. MONTANA DEPT. OF FISH & GAME, ADMINISTRATOR OF PARKS 1420 EAST 6TH ST. HELENA, MT 59620 449-3750	RON HOLIDAY	NO IMPACT BY PROJECT
4. MONTANA NATURAL STREAMBED & LAND PRESERVATION ACT [redacted]PARK COUNTY CONSERVATION DISTRICT	LOCAL OFFICER	SITE INSPECTION & ISSUANCE OF "310" PERMIT
5. MONTANA DEPT OF HEALTH & ENV. SCIENCES, WATER QUALITY DIVISION CAPITOL STATION HELENA, MT 59620 449-2406	FRED SCHUMAN	NO ACTION TAKEN
6. MONTANA DEPT. OF NATURAL RESOURCES & CONSERVATION, WATER RIGHTS BUREAU 32 SOUTH EWING HELENA, MT 59620 449-3962	THERESA MCLAUGHLIN	PROVISIONAL PERMIT ISSUED
7. MONTANA DEPT. OF NATURAL RESOURCES & CONSERVATION, FLOODPLAIN MGMNT. SECTION 32 SOUTH EWING [redacted]HELENA, MT 59620 449-2864		PROJECT IS NOT IN FLOODPLAIN
8. MONTANA HISTORICAL SOCIETY 225 NORTH ROBERTS ST Helena MT [illegible]	MARCIA [illegible]	HAD TO CONTRACT AN ARCHAEOLOGICAL [illegible]

C. Power Contract

1. The contract negotiation process with the Montana Power Company was in general extremely difficult, indirect, unclear, slow, etc. Their contract people projected a helpful attitude and yet were not helpful. (Their engineers and field personnel, however, were totally helpful.) Since MPC was only willing to sign the Public Service Commission approved tariff contract (a contract which is not reliable in sales price or duration), there really was not much negotiation. We met in Butte two times, once to describe the project and see what their posture was, and once to sign the standard tariff contract. Between these meetings, there were three and one-half (3½) months with many phone calls and letters asking for an Intent to Purchase, for metering requirements and costs, and for a contract in the mail.

2. The contract can be obtained in its entirety from MPC or the PSC. The price for power is recomputed yearly with no guarantees of price floors or ceilings. Also, there is a reserved jurisdiction clause that allows law changes to void the contract. There are also serious liability terms that need to be understood thoroughly.

3. The prospective negotiators for contracts with MPC should start early, be prepared with their project's description, and be determined. Also, records of all communications with MPC should be kept and copied to the PSC.

D. Equipment

Pipe length, diameter and material were chosen and iterately optimized by weighing added costs versus added benefits (increasing pipe length, diameter and material quality increases power sales revenue through less friction and larger head, but may cost more than it's worth), then a nozzel power versus head and flow curve was generated and sent to turbine manufacturers along with a list of specifications. The manufacturer paired these specifications with one of their standard turbines, and since it matched fairly well, suggested this turbine. Generator and switchgear line drawings and bids were solicited from one trusted source only and accepted after review by project and utility engineers. Following is more description of the equipment used and its specifications.

Recommendations for equipment solution would include thoroughly researching existing manufacturers and obtaining many bids unless good sources are already known. More manufacturers

are coming into the small hydro business and forcing the market to be more competitive. Bids vary widely. If not much is known about certain manufacturers, make trips to check out their operation. Make sure that you are buying good equipment and not cheaping out on critical components whose costs is a relatively small percentage of the whole project cost. Buy equipment that is absolutely safe.

Ring-Tite PVC
Pressure Pipe

Designed for Installed-Cost Savings

Save in handling costs. Most sizes can be handled manually, so there is no need for costly installation equipment. Use the backhoe for excavating and backfilling only. Dig more trench, lay pipe faster, save more in costs per foot installed.

Save in excavating and backfilling. No need to make the trench large enough to work in. Joints can be made "on-top." The trench width can be limited to the pipe diameter plus four-inch minimum space on each side of the pipe. This means less earth to be excavated, backfilled and tamped, and savings in time and equipment costs.

Save on fittings and thrust blocks. J-M Ring-Tite PVC pipe can be curved as shown in the table to eliminate many corners that would require elbows and bends. The costs of these items and labor are saved.

Min. Radii of Curvature

Size (in)	Radius (feet)
1½	38
2	50
2½	63
3	75
4	100
6	150
8	200
10	250
12	300

Description

Pipe conforms to ASTM D2241 for Standard Dimension Ratios: 125 psi pipe–SDR 32.5; 160 psi pipe–SDR 26; 200 psi pipe–SDR 21. Extruded from clean, virgin, approved class 12454-A PVC resin compound conforming to ASTM Specification D1784. Rubber rings conform to ASTM D1869 and F477.

Applications

Rural water, agricultural and turf irrigation pipelines. The pressure rating of the pipe–125 psi, 160 psi, or 200 psi–indicates the maximum allowable sustained pressure with a long-term 2 to 1 safety factor.

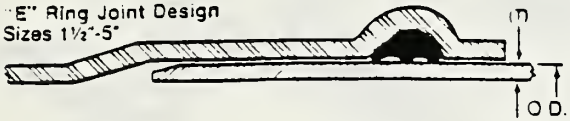
Meets Accepted Standards

J-M Ring-Tite PVC pipes are tested to levels as shown in ASTM D2241.

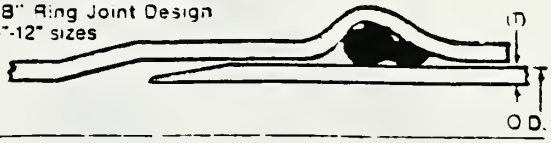
	ASTM D2241		
Test	**125 psi**	**160 psi**	**200 psi**
Long Term Pressure Test 1000 hours	260	340	420
Quick Term Burst Test	400	500	630
Acetone Immersion Test A measure of proper fluxing and precise temperature control	20 min.	20 min.	20 min.
Flattening Test Tests extrusion quality and ductility under slow loading conditions.	60% in 2-5 min.	60% in 2-5 min.	60% in 2-5 min.

Pipe Dimensions, Fittings & Adapters

"E" Ring Joint Design
Sizes 1½"-5"



"B" Ring Joint Design
6"-12" sizes



Nominal Size	1½†	2†	2½	3	4	5*	6	8	10	12
O.D. (Average)	1.900	2.375	2.875	3.500	4.500	5.563	6.625	8.625	10.750	12.750
Min. Wall (125 psi)	0.060	0.073	0.088	0.108	0.138	—	0.204	0.265	0.331	0.392
Thickness, (160 psi)	0.073	0.091	0.110	0.135	0.173	0.214	0.255	0.332	0.413	0.490
(T), Ins. (200 psi)	0.090	0.113	0.137	0.167	0.214	0.265	0.316	0.411	0.511	0.606
Wt. Lbs./Std. Length										
(125 psi)	4.6	7.0	10.2	15.3	25.2	—	55.0	92.5	145.0	204.0
(160 psi)	5.5	8.6	12.6	18.8	31.1	47.7	67.7	115.0	180.0	254.0
(200 psi)	6.8	10.6	15.6	23.1	38.2	58.5	83.1	141.0	200.3	311.0

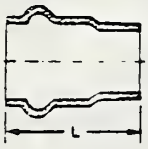
All dimensions are in inches. Laying length for all sizes is 20' ± 1". O.D. dimensions conform to Iron Pipe Size (I.P.S.)
* 5" not inventoried—Available only on special request.
† Available in McNary plant shipping area only.

90° Bend

Pipe Size	Radius (R)
1½"	3"
2"	4"
2½"	6"
3"	9"
4"	12"

See "other available fittings"

Male Adaptor (Threaded)



Nom. Size	L
1½"	5.8"
2"	6.2"
2½"	7.0"
3"	7.5"
4"	8.4"

Tee

Pipe Size
1½"
2"
2½"
3"
4"

Also available with branch leg and with threaded leg

45 Ell

Pipe Size
1½"
2"
2½"
3"
4"

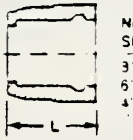
Also available bell x bell

Reducer

Nom. Size Spigot Bell	L
2"x1½"	9.1"
2½"x2"	9.6"
3"x2½"	10.5"
4"x3"	12.0"
*6"x4"	8.0"
*8"x6"	8.0"

*Available in Transite®

Transite® Reducing Adaptor (Transite or C. I. Ring-Tite Bell to PVC spigot end)



Nom. Size	L	O.D.
8"x6"	6.2"	9.33"
6"x4"	5.2"	7.13"
4"x3"	4.7"	5.16"

Transite® Heavy Tapped Coupling

Nom. Size	L	O.D.
8"	15.00"	11.20"
6"	15.00"	9.66"

Outlet Size	Type	Material
¾-2"	IPS	Brass
¾-1"	AWWA	Brass

4", 6" and 8" IPS Transition Gasket PVC to Ring-Tite Cast Iron Fittings

*These adaptors cut from TRANSITE asbestos-cement pipe stock. TRANSITE is a Johns-Manville registered trademark for its brand of asbestos-cement products.

Make Tight Joints in Seconds

That's all there is to it, a simple procedure that makes tight joints in seconds. No waiting for solvent cement to dry. No field-mixing or application of cement, or adjusting set-up times due to weather conditions. Joint is ready right away for full pressure. And each joint is an expansion joint. No need to "snake" the pipe. The Ring-Tite joint saves time and money.

Clean Bell and End. Be sure no dirt can lodge between the ring and the bell or pipe end.

Set Ring in Groove...with painted edge facing toward end of bell.

Lubricate Pipe End...with a light film of lubricant.

Push End In...so that reference mark on spigot end is flush with end of bell.

Cut, Bevel, and Tap Quickly

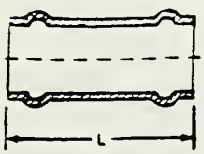
Cut with saw, as shown, or other approved PVC cutting tool.

Bevel ends with hand beveling tool, as shown, or Pilot tool

Mark cut ends as shown, using another end of same-size pipe to locate the reference mark accurately.

Tap with saddle assembly and tapping tool as shown. Use tapping tool suitable for PVC pipe only.

Couble Bell Coupling
For joining two spigot ends.
For adapting to steel pipe.
For making repairs.



Nom. Size	PSI Rating	L	Wt./lbs.—per Cplg.
1½"	200	7.0"	0.3
2"	200	7.5"	0.5
2½"	200	8.0"	0.8
3"	200	8.8"	1.2
4"	200	9.9"	2.0
6"	200	12.3"	5.8
8"	200	14.0"	10.3

Typical Physical and Chemical Properties and Capacities

Property	R-T PVC Pipe	ASTM Test Method	ASTM D 2241
ISO Hoop Stress at 73F			
Short Term Bursting Strength (PSI)		D1599	6,400
1,000 Hour Strength (PSI)		D1598	4,200
Working Pressure Rating			
73F (% of rating at 73F)	100%		
80F (% of rating at 73F)	88%		
100F (% of rating at 73F)	60%		
Chemical Resistance at 73F			
Acids	Excellent		
Salts—Bases	Excellent		
Aliphatic Hydrocarbons (including crude oil)	Good		
Physical Properties of Std. Test Specimens			
Tensile Strength (psi) at 73F		D638	7,000
Thermal Expansion (In./100 ft./50°F change)	2"		
Fire Resistance	Self Extinguishing		
Coefficient of Flow			
Williams-Hazen	C=150		

Tee and Ell elements are solvent-welded at the Johns-Manville plant under controlled conditions. The fittings are inspected to insure that a good solvent cement joint has been obtained.

Other Available Fittings

PVC Adaptor, Transite spigot x PVC bell—Sizes 3", 4", 6".

8" Adaptor, Ring-Tite PVC bell x Transite Spigot—Size 8" only.

Bell Adaptor and Spigot Adaptor—1½", 2", 2½", 3", 4".

Tee with branch leg reduced—1½" on 2", 1½" and 2" on 2½", 1½" and 2" and 2½" on 3", 2" and 2½" and 3" on 4".

Tee with threaded leg outlet—1½"x1½"x1½", 1", ¾" or ½"; 2"x2"x1½", 1¼", 1", ¾", or ½"; 2½"x2½"x2", or 1½"; 3"x3"x3"; 4"x4"x4".

Cap-bell and Cap-spigot—1½", 2", 2½", 3", 4".

90° elbow (bellxthread)—1½"x1", 1½"x1½", 2"x1½", 2"x2".

The physical (or chemical) properties of Johns-Manville PVC pipe represent typical, average values obtained in accordance with accepted test methods and are subject to normal manufacturing variations. The indicated minimum values are as shown. This information is supplied as a technical service and is subject to change without notice. Check the Johns-Manville Customer Service Center or Local Representative to assure current information.

Permastran

Water distribution
and transmission lines

European markets

Fire lines

Industrial pipelines

Description
Permastran is a fiber glass composite pipe composed of an inner core of PVC (polyvinyl chloride) overwrapped with continuous roving fiber glass bonded with epoxy resin. The fiber glass and epoxy resin provide Permastran with its hydrostatic strength while the PVC core provides a corrosion resistant, watertight internal core.

Advantages
Permastran pipe has been designed to withstand rated pressure with a factor of safety consistent with industry practice. Quality is assured by 100% hydrotesting each length to 700 psi. It has also been designed to withstand typical soil loads with an adequate factor of safety. Permastran is a flexible conduit and the installation should be engineered using accepted methods.

By combining lightweight yet surprisingly strong materials, Permastran offers the user a low installed cost, and a reliable product. Its use can result in lower costs to the owner, savings in labor to the contractor and a properly designed system for the engineer.

Approvals and acceptance
Underwriters' Laboratories Inc. listed
Factory Mutual approved*
National Sanitation Foundation
ASTM
Corps of Engineers

Sizes
4", 6", 8", 10", 12" nominal diameters have cast iron OD's.

Laying lengths
Standard 20' lengths ± 1"

Pipe size (in.)	Weight (lbs./20' length)
4	30
6	53
8	91
10	120
12	171

Temperature service range
Use range: +32°F to 140°F
(0°C to 60°C)
Expansion/Contraction:
1.5 in./100 ft./50°F rise
(0.125 cm./m./10°C)

*As a matter of policy, Factory Mutual approval applies only to any piping materials operated at up to 200 psig.

Flow characteristics
Permastran's long 20' laying lengths, combined with its glass-smooth interior and oversized ID's make possible a pipe with the greatest carrying capacity of any major recognized product on the market today. The Hazen & Williams coefficient of flow is C = 150. The flow chart below indicates the flows, velocities and head losses for Permastran. Please refer to TR-602A, "Flow Capacity Comparison" for more detailed information.

350 psi pressure rating
The pressure rating is the maximum recommended operating pressure at 73°F. An additional 42 psi is allowed for surge in the design based on a stoppage of flow of 2 ft. per second. The pressure

	Pipe size, inches									
	4		6		8		10		12	
Flow (gpm)	Velocity (ft./sec.)	Head loss (ft./100 ft.)	Velocity (ft./sec.)	Head loss (ft./100 ft.)	Velocity (ft./sec.)	Head loss (ft./100 ft.)	Velocity (ft./sec.)	Head loss (ft./100 ft.)	Velocity (ft./sec.)	Head loss (ft./100 ft.)
100	2.02	0.33								
200	4.03	1.17	1.92	0.19						
300	6.05	2.49	2.88	0.41	1.67	0.11				
400	8.07	4.24	3.84	0.70	2.23	0.19				
500	10.09	6.41	4.80	1.05	2.79	0.28				
600			5.77	1.48	3.34	0.39	2.20	0.14		
700			6.73	1.97	3.90	0.52	2.56	0.19		
800			7.69	2.52	4.46	0.67	2.93	0.24	2.07	0.10
900			8.65	3.13	5.02	0.83	3.30	0.30	2.33	0.13
1000			9.61	3.80	5.57	1.01	3.66	0.36	2.59	0.16
1500					8.36	2.14	5.49	0.77	3.89	0.33
2000							7.33	1.31	5.19	0.57
2500							9.16	1.98	6.48	0.85
3000									7.78	1.20
3500									9.08	1.59

rating is based on the long-term design considerations determined in accordance with ASTM D 2992 and ASTM D 2996. Each length of Permastran is hydrostatically tested to 700 psi. One sample in 100 is tested to destruction and must meet a minimum burst of 1600 psi.

For maximum recommended operating pressures at temperatures higher than 73°F., utilize the following percentages of rated pressure.

Temperature (°F)	350 psi (%)
73	100
80	93
90	85
100	80
110	70
120	60
130	55
140	50

It should be noted that temperatures refer to the temperature of the water being conveyed and not the atmospheric temperature.

Corrosion resistance

Internal. Permastran is resistant to all normal waters, dilute acids and alkalies, soap solutions, inorganic salt solutions, and crude oil with low aromaticity, using oil-resistant rings.

External. Resistant to electrolytic and galvanic corrosion. Resistant to all aqueous soil acids, alkalies (ph 1.0-12.0), gasoline and crude oil spillage when oil-resistant rubber rings are requested and supplied.

Note: Since the thermoplastic line is not immune to a number of organic solvents or strong oxidizing agents, any industrial application should be analyzed for possible harmful chemicals in the fluid or surrounding soil.

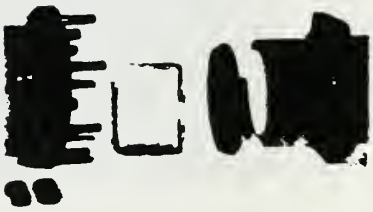
Abrasion

The PVC liner in Permastran is well suited to applications where abrasive conditions are anticipated. In extremely abrasive conditions, wear must be anticipated. Laboratory tests through the years have indicated that PVC exhibits an abrasive resistance approximately equal to steel or glazed vitrified clay pipe.

Physical characteristics

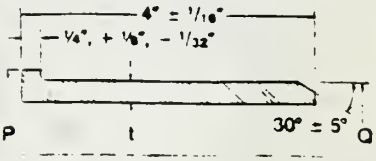
Joint design and dimensions
Permastran pipe is manufactured with an integral bell and spigot end. They are factory made to precise dimensions to accommodate the joining method for Permastran.

The rubber "B" ring, which is "locked-in" the ring groove at the time of manufacture, is used to make a tight seal and helps center the spigot end of the pipe in the bell.



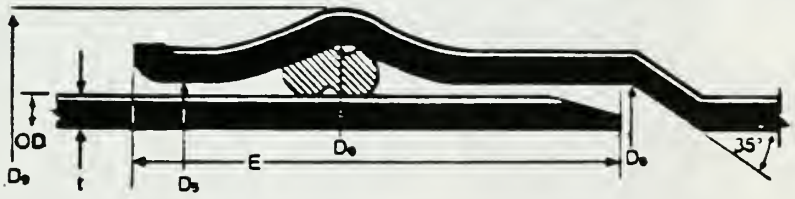
Assembly at fittings and valves
In 4", 6", 8", 10" and 12" diameters, cast iron slip ring and mechanical joint fittings and valves are available. If mechanical joint fittings or valves are assembled on Permastran pipe, a PVC mechanical joint stiffener sleeve *must* be used to prevent possible damage to the pipe. The bolts should not be tightened more than 50 ft. lbs.

PVC mechanical joint stiffener sleeve



Dimensions (inches)

Pipe size	P	Q	t (min.)
4	4.50	4.47	.190
6	6.62	6.48	.240
8	8.62	8.52	.350
10	10.75	10.51	.390
12	12.75	12.50	.480



Dimensions (inches)

Pipe size	D_s/D_e	D_e	D_e	OD	t	E
4	4.85	5.70	6.01	4.80	.150	3.75
6	6.96	7.94	8.34	6.90	.190	4.50
8	9.12	10.29	10.81	9.05	.245	5.25
10	11.19	12.54	13.21	11.10	.270	6.14
12	13.30	14.79	15.64	13.20	.325	6.73

Design considerations

Permastran pipe is designed in accordance with procedures outlined in ASTM D 2992, "Standard Method for Obtaining Hydrostatic Design Basis for Reinforced Thermosetting Resin Pipe and Fittings" and ASTM D 2996, "Standard Specification for Filament-Wound Reinforced Thermosetting Resin Pipe."

Permastran is a Type 1 (Filament-wound) Grade 1 (Glass fiber reinforced epoxy resin pipe), Class H (Thermoplastic resin liner) pipe product. Its classification in accordance with ASTM D 2996 is 11 HZ 5001. This designation is developed as follows:

Type	1	Filament-wound
Grade	1	Glass fiber reinforced epoxy resin pipe
Class	H	Thermoplastic resin liner
	Z	Static pressure strength (hoop stress) exceeding 31,500 psi (217 M Pa)
	5	Minimum short term rupture strength hoop tensile stress 60,000 psi (426.3 M Pa)
	0	Longitudinal tensile strength, unspecified*
	0	Longitudinal tensile modulus, unspecified*
	1	Apparent stiffness factor at 5% deflection, minimum 40 in.^{2}-lbs./in. (46cm.^{2}-kg./cm.)

*There is no longitudinal pipe loading with rubber ring joints under hydrostatic pressure.

Permastran is designed by using the ISO formula for hoop stress:

$$S = \frac{P(D-t)}{2t}$$

Where:
S = Hoop stress, psi
P = Internal pressure, psi
D = Average outside diameter, in.
t = Minimum wall thickness, in.

The assumptions to be made in designing Permastran are as follows:
1. Determine HDB by Procedure B, ASTM D 2992.
2. All strength comes from the fiber glass.
3. Fiber glass MR = 160,000 psi (1102.9 M Pa).
4. 2:1 safety factor.
5. 350 psi rating.
6. 42 psi surge allowance.

Example of 12" Permastran

$$S = \frac{P(D-t)}{2t}$$

Where:
S = 160,000 psi
P = (Pw + Ps) (SF)
SF = 2
D = 13.20"

Therefore:

$$160{,}000 \text{ psi} = \frac{(350+42)\,(2)\,(13.20-t)}{2t}$$

320 000t = 10348.8 − 784t
t = .032" (glass only)

Since the amount of glass is controlled by weight, we convert the glass thickness into glass weight.
W = (π) (OD) (t) (L) (P)

Where:
OD = 13.20"
t = .032"
L = 250"
P = Specific gravity of glass (lbs./in.^{3})

Therefore:
W = (3.14) (13.20) (.032) (250) (.0917)
W = 30.4 lbs.

With a glass/resin ratio of 60/40, the

$$\text{glass/resin weight} = \frac{30.4}{.60} = 50.7 \text{ lbs.}$$

Finished pipe weight would be:

Fiber glass	30.4 lbs.
Resin	20.3 lbs.
PVC core	120.3 lbs.
Total weight/length (approx.)	171.0 lbs.

Trench preparation
Bedding
Backfill

The slim profile of Permastran allows it to be installed with less excavation than most other pipe materials. In addition to allowing substantial cost savings, this gives Permastran a distinct advantage in tight areas or in locations where other installed utility lines or substructures are close to the trench.

Backfill material in the pipe zone shall be free of large stones or clods more than 1½" in diameter, hand placed and hand tamped to fill all space around pipe with particular attention to the sides of pipe. Backfill material may be either Class I, II, III, or IV.

Excavation for bells shall be provided so that pipe is uniformly supported along its length. Usually, loose material left by the excavator on the trench bottom will provide an adequate support for bedding the pipe barrel. Where the excavator cuts a very clean bottom, soft material may be shaved down from the trench sidewalls to provide the needed soil blanket.

If the trench bottom is rocky or hard, as in shale, place a 6" layer of selected backfill material to provide a cushion for the pipe. In rock excavation, it is necessary that rock be removed so that, in no place, will it be closer than 6" from the pipeline. After excavation, a bed of sand or selected backfill at least 6" deep should be placed on the bottom of the trench and the pipe placed on this cushion. A pipeline of any material which, in the absence of a bedding cushion, rests directly on an edge of rock is subject to breakage under the weight of backfill load, surface load or earth movements.

The initial backfill should be compacted by tamping around the sides of the pipe. Do not use power tamping tools within 3" of the sides of the pipe or directly over the top of the pipe.

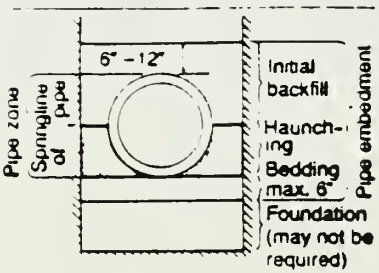
See TR-712A, "Permastran Installation Guide" for specific illustrations and details.

Completing the backfill

The balance of backfill need not be as carefully selected as the initial material. Care should be taken, however, to avoid including large stones which could damage the pipe by dropping on it or by being forced down on it under the weight of final backfill.

The remainder of the backfill should be placed and spread in approximately uniform layers in such a manner to completely fill the trench with a uniformly dense backfill load on the pipe and avoid unfilled spaces in the backfill. Rolling equipment should not be used until a minimum of 30" of backfill material has been placed over the top of the pipe.

Note: The top area of the bells can be left exposed for visual inspection during pressure testing, *if desired*. However, sufficient backfill must be placed on the pipe to restrain the pipe from moving during pressure testing. After testing, the joints should be backfilled in the same manner as the pipe.



Live loads

Live load effect must be considered in all underground pipeline installations except at depths over 12'. Live loads have little effect except at shallow depths. However, in extremely shallow installations, Permastran will react to high live loads by deflecting slightly under load and then returning to its original shape when load is removed. Under severe conditions, an overlying roadway directly above the pipe may be damaged. For this reason, design precautions should be taken when Permastran is buried under a roadway with less than 3' of cover. A minimum of 18" cover is recommended where frost penetration and surface loads need not be considered. Where frost is a factor, pipe should be buried 6" below greatest recorded frost penetration.

Live loads on a pipe produced by a hydrohammer can be extremely high. Therefore, a hydrohammer should not be used to compact soil within 3' of the top of the pipe, and then only if backfill soil at the sides of the pipe has been previously compacted to at least 85% Proctor density.

Height of cover

Permastran is a flexible conduit and the installation can be engineered using standard flexible pipe concepts. Pipe installed as outlined above will perform well under most conditions.

Thrust control

Thrust control is required wherever the pipeline: changes direction, as at tees and bends; changes sizes, as at reducers; stops, as at deadends and valves. The type and extent of thrust control required depends on pipe size, pressures, type of soil and type of fitting. Thrust control is normally designed by the engineer. Location, type and size are his responsibility and should be included in the project plans and specifications.

Short form specifications

Handling
Permastran pipe is much lighter in weight than other pipe materials. All sizes may be manually handled.

Joint
The single rubber "B" ring joint of Permastran is assembled in the field by bar and block or suitable puller. The light weight of Permastran allows it to be easily joined in the trench without the effort or danger commonly associated with extremely heavy materials.

Fittings and accessories
4", 6", 8", 10" and 12" pipe can be used directly with C.I. dimensional fittings, both slip joint and mechanical joint. Caution should be exercised when using MJ fittings in that the bolts should not be over torqued. Johns-Manville recommends a maximum of 50 ft. lbs. torque. A torque wrench must be used with MJ fittings, along with a PVC MJ stiffener sleeve.

Scope
This specification designates general requirements for Permastran, a composite fiber glass pipe with integral bell and spigot joints for conveying potable water, industrial water, sewer force mains, or fire lines.

Pipe
Pipe shall be suitable for use at 350 psi at 73°F with a 2:1 safety factor. Standard laying lengths shall be 20' plus or minus 1". Manufacturer has option of supplying up to 15% of each size in random lengths (6' minimum including bells and rings).

Fittings
4", 6", 8", 10" and 12" can be used directly with C.I. dimensional fittings. If MJ fittings are used, a PVC MJ stiffener sleeve *must* be used. Pipe and fittings shall be assembled with a lubricant as recommended by the manufacturer of the pipe.

Physical and chemical requirements
Pipe shall be designed to pass all tests at 73°F (±3°F).

a. Quick burst test
Randomly selected samples tested in accordance with ASTM D 1599 shall withstand, without failure, pressures listed below when applied in 60-90 seconds. J-M rubber ring seal test jigs shall be used.

Pipe size (in.)	Pressure (psi)
4	1600
6	1600
8	1600
10	1600
12	1600

b. Routine hydro test
All pipe shall be 100% hydrotested to 700 psi, and held for 5 seconds.

c. Core bond vise crush test
Square cut lengths, 1" ± .25", shall be flattened a minimum of 100% of the inside diameter without disbondment. Samples shall be placed in a vise with plates 1" wide and pipe axis parallel to the vise plates, and shall be crushed in less than one minute.

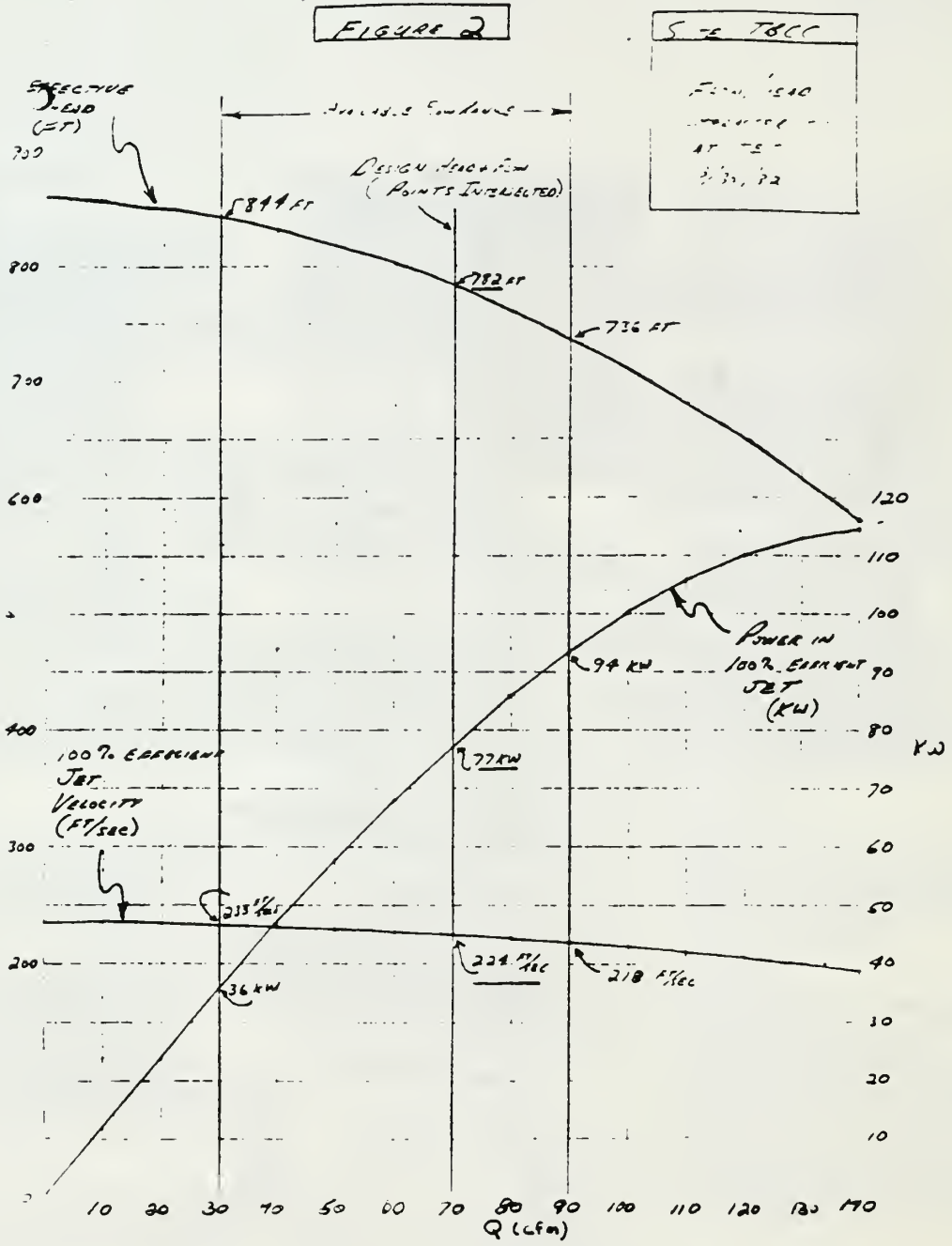
d. Drop impact test
Square cut lengths, 8" ± 0.5", shall withstand, without failure, two impacts at the same location of a falling 30-lb. missile with a 2" radius nose, at the following levels.

Pipe size (in.)	Impact (ft. lbs.)
4	130
6	130
8	130
10	160
12	190

There shall be no visible evidence of shattering or splitting when the energy is imposed.

e. Epoxy cure
A surface area of approximately 1" square on each sample shall be manually worked with a cloth saturated with acetone, for a time period of five minutes. Any evidence of tackiness or solubility of the epoxy will constitute failure.

FIGURE 2


Effective Head (FT)
Design Region (Points Interpolated)
814 FT
782 FT
736 FT
Power in 100% Efficient Jet (KW)
94 KW
77 KW
36 KW
100% Efficient Jet Velocity (FT/sec)
233 FT/sec
224 FT/sec
218 FT/sec
KW
Q (cfm)

Effective head loss through piping to the point of the needle nozzle was determined by using the Hazen and Williams friction loss equation for piping. See below chart.

Minor losses due to bends and valves in the steel piping at the power house were calculated and found to be about one foot. See copy of enclosed minor loss calculations. These minor losses were then neglected.

The losses in the length of steel piping were also neglected.

The over-ground aluminum was treated as pvc in friction characteristics for simplicity since it is so short (1/28) compared to total pipe length. See copy of enclosed head loss equation and parameters.

Hazen and Williams Equation for head loss in pipes:

The Hazen and Williams Formula expressing head loss in feet of water per 100 feet of pipe is as follows:

$$H_L = \sum_{i=1}^{n} .2083\left(\frac{100}{C}\right)^{1.85} \frac{q_i^{1.85}}{d_i^{4.8655}}$$

where C is the roughness coefficient (150 for PVC)

q = gallons per minute

d = pipe inside diameter in inches

n = number of different types of pipes

Information fed into the Hazen and Williams Equation is as follows:

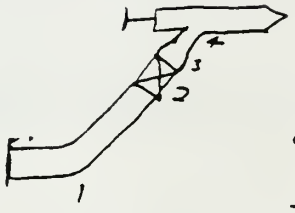
	LENGTH (FT)	INSIDE DIA. (IN)	
ALUMINUM	220	6.00	} LOOKED AT AS ONE
PVC 125	800	6.217	}
PVC 160	300	6.115	
PVC 250	400	5.993	
PERMASTRAN	4460	6.520	

	SUBSCRIPTS (n = 4)			
VARIABLES	1	2	3	4
L	1020	300	400	4460
D	6.217	6.115	5.993	6.520

Minor Losses in Piping

Tom Brock
Cascade Creek
4/27/80 ES&E

$$H = \frac{KV^2}{2g} = \frac{K\,Q^2/A^2}{2g}$$



1. 6 inch 45°
2. 6 inch gate valve
3. 6 inch x 5 inch reducer
4. 5 inch 45°

$$H_{\substack{\text{total}\\\text{minor}}} = \sum_{i=1}^{4} K_i \frac{Q^2/A_i^2}{2g}$$

$$H_{\substack{\text{minor}\\\text{loss}}} = \frac{Q^2}{2g}\left[\frac{K_1}{A_1^2} + \frac{K_2}{A_2^2} + \frac{K_3}{A_3^2} + \frac{K_4}{A_4^2}\right]$$

$$H_{\substack{\text{minor}\\\text{loss}}} = \frac{Q^2}{2g}\left[\frac{K_1 - K_2}{A_1^2} + \frac{K_3 - K_4}{A_3^2}\right]$$

$A_1 = A_2$
$A_3 = A_4$

$$H_{\substack{\text{minor}\\\text{loss}}} = \frac{1.5^2}{2g}\left[\frac{.1 + .04}{\left[\frac{\pi (.5)^2}{4}\right]^2} + \frac{.1 + .1}{\left[\frac{\pi (.5)^2}{4}\right]^2}\right]$$

$K_1 = .1$
$K_2 = .04$
$K_3 = .1$
$K_4 = .1$

$Q_{max} = 1.5$ cfs
A_1 for 6 in dia
A_3 for 5 in dia

$$H_{\substack{\text{total}\\\text{minor}}} = .50 \text{ ft}$$

ITEM 1

SMALL HYDROELECTRIC SYSTEMS & EQUIPMENT

HYDROPOWER ADVISORY SERVICE

5141 Wickersham Acme, Washington 98220 USA
Phone. (206) 595-2312

PROPOSAL AND CONTRACT

TO: Mr. Roger Kirk
PARAGON ENGINEERING & DESIGN
P.O. Box 1143
Bozeman, MT 59715

Date May 17, 1982

Proposal No. 1377-1-0050-1012

Phone (406) 587-4511

WE PROPOSE TO FURNISH LABOR AND MATERIAL IN STRICT ACCORDANCE WITH THE PLANS AND SPECIFICATIONS AS FOLLOWS:

THE TURBINE

A one nozzle, 13.77" P.D. impulse turbine to run at 1,800 R.P.M. The nozzle will be of the needle type. The needle and cone will be made of 316 stainless steel. The wheel will be a machined single piece casting of 316 stainless steel, 13.77" pitch diameter, with 22 buckets ground to form and dynamically balanced. The bearings used will be anti-friction, oil bath bearings. Both bearings will be mounted on one side of the turbine. The wheel will be overhung and flange mounted. The turbine housing will be fabricated of 3/4" steel plate with a 1/4" steel plate inspection door for easy access to the turbine runner, needle nozzle and deflector. The needle nozzle will be hand-over hydraulic with a nominal jet size of 1.17" maximum. The turbine base will be fabricated of 12" wide flange "I" beam with integral generator base. The intake to the turbine will be flanged for 6" pipe.

SAFETY SHUTDOWN

The turbine will be equipped with a solenoid trip device to shut down the turbine in the event of a systems fault.

DRAWINGS AND INSTRUCTIONS

The turbine will be supplied with installation drawings and instruction manuals for complete packaged hydroelectric plant.

DELIVERY TIME

Small Hydroelectric Systems & Equipment, Inc. expect to complete the proposed turbine within four months after receipt of firm order. This is F.O.B. our plant in Acme, Washington.

PRICE: FOR THE TOTAL SUM OF ..... : Stated on Page 2.

CONDITIONS: As stated below-

It is understood and agreed that we shall not be held liable for any loss, damage or delays occasioned by fire, strikes, or material stolen after delivery upon premises, lockouts, acts of God, or the public enemy, accidents, boycotts, material shortages, disturbed labor conditions, delayed delivery of materials from Seller's suppliers, force majeure, inclement weather, floods, freight embargoes, causes incident to national emergencies, war, or other causes beyond the reasonable control of Seller, whether of like or different character, or other causes beyond his control. Prices quoted in this contract are based upon present prices and upon condition that the proposal will be accepted within thirty days. Also general conditions which are standard for specialty contractors.

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GUARANTEE

Small Hydroelectric Systems & Equipment, Inc. guarantee that the equipment furnished under this contract will be free from defects in material and workmanship. We will guarantee satisfactory operation of the equipment supplied by our company for a period of one year after the delivery of the equipment.

NOTE: The 13.77" pitch diameter runner operates at a head range of 782'feet to 908 feet.

PRICE: FOR THE TOTAL $ 910.00

It is understood upon premi... materials ... caused ... trac... by ...

THIS PROPOS... TRACT

SUBMITTED Gary

SMALL HYDROELEC... & EQUIPMENT, INC.

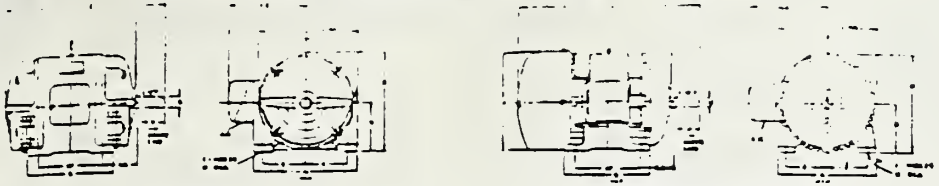
NOTE: If equipment is built, and buyer is ...

PACEMAKER® SQUIRREL CAGE MOTORS

GENERAL DIMENSIONS FRAMES 143T TO 449T

ITEM 3

GENERAL PURPOSE MOTORS DIMENSIONS IN INCHES



DRIP PROOF — ENCLOSED FAN COOLED (TEFC) EXPLOSION PROOF FAN COOLED (TEXP)

FRAME SIZE	A	B	C DRIP PROOF	C TEFC TEXP	D+	E	2F	H	O DRIP PROOF	O TEFC TEXP	P DRIP PROOF	P TEFC TEXP	SHAFT EXTENSION N W	SHAFT EXTENSION U+	SHAFT EXTENSION V	SHAFT EXTENSION KEYWAY	AA Size of Conduit	AB Max.	BA	APPROX. NET WGT IN LBS. DRIP PROOF	APPROX. NET WGT IN LBS. TEFC TEXP
143T	7 00	5 00	11 50	12 04	3 50	2.75	4 50	344	7 13	7 38	7 25	7 76	2.25	875	2 00	188 x 094	3/4	6 94	2.25	45	63
145T	7 00	6 00	12 50	13 04	3 50	2.75	5 50	344	7 13	7 38	7 25	7 76	2.25	875	2 00	188 x 094	3/4	6 94	2.25	54	73
182T	9 00	6 50	12 62	14 35	4 50	3.75	4 50	406	8 94	9 12	8 88	9 24	2.75	1 125	2 50	250 x 125	3/4	7 26	2.75	75	100
184T	9 00	7 50	13 62	15 35	4 50	3.75	5 50	406	8 94	9 12	8 88	9 24	2.75	1 125	2 50	250 x 125	3/4	7 26	2.75	90	115
213T	10 50	7 50	15 50	17 91	5 25	4 25	5 50	406	10 44	10 74	10 38	11 09	3 38	1 375	3 12	312 x 156	1	9 94	3 50	130	172
215T	10.50	9 00	17 20	19 41	5 25	4 25	7 00	406	10 44	10 74	10 38	11 09	3 38	1 375	3 12	312 x 156	1	9 94	3 50	154	200
254T	12.50	10.75	20.49	22.79	6 25	5.00	8 24	531	12 37	12 55	12 24	12.71	4.00	1 625	3.75	375 x 188	1 1/4	10 75	4 25	227	296
256T	12.50	12.50	22.25	24 55	6 25	5 00	10 00	531	12 37	12 55	12 24	12.71	4 00	1 625	3 75	375 x 188	1 1 4	10 75	4 25	256	388
284T	14.00	12.50	23.36	26 60	7 00	5.50	9 50	531	13 88	14 22	13 76	14.44	4 62	1 875	4 38	500 x 250	1 1/2	12 30	4.75	330	460
284TS	14.00	12.50	21.99	25.23	7 00	5 50	9 50	531	13 88	14 22	13.76	14 44	3 25	1 625	3.00	375 x .188	1-1/2	12 30	4 75	330	460
286T	14.00	14.00	24 86	28.10	7 00	5 50	11 00	531	13 88	14 22	13.76	14 44	4 62	1 875	4 38	500 x 250	1 1/2	12.30	4 75	361	516
286TS	14 00	14.00	23.49	26.73	7 00	5 50	11 00	531	13 88	14 22	13.76	14 44	3 25	1 625	3 00	375 x 188	1 1/2	12.30	4 75	361	516
324T	16.00	14.00	25.99	29 63	8.00	6.25	10 50	656	15 88	16 43	15.76	16.85	5 25	2.125	5.00	500 x 250	2	14 44	5 25	432	703
324TS	16.00	14 00	24.49	28.13	8 00	6.25	10 50	656	15 88	16 43	15.76	16.85	3 75	1 875	3 50	500 x 250	2	14 44	5.25	432	705
326T	16.00	15.50	27.49	31.13	8.00	6 25	12.00	656	15.88	16.43	15 76	16 85	5.25	2.125	5.00	500 x 250	2	14 44	5.25	522	756
326TS	16.00	15.50	25.99	29.63	8.00	6 25	12.00	656	15 88	16 43	15.76	16 85	3.75	1 875	3.50	500 x 250	2	14 44	5 25	522	756
364T	17.26	15.12	28.63	32.88	9 00	7 00	11 24	656	17.57	18 25	17.14	18 50	5 88	2.375	5.62	625 x 312	3	14 94	5 88	625	840
364TS	17.26	15.12	26.50	30.75	9 00	7 00	11 24	656	17 57	18.25	17 14	18.50	3 75	1 875	3.50	500 x 250	3	14 94	5 88	625	840
365T	17.26	16.12	29.63	33 88	9.00	7 00	12.24	656	17 57	18.25	17 14	18.50	5 88	2.375	5.62	615 x 312	3	14 94	5 88	650	910
365TS	17.26	16.12	27.50	31.75	9 00	7.00	12.24	656	17.57	18.25	17 14	18.50	3.75	1.875	3 50	500 x 250	3	14 94	5 88	650	910
404T	19 40	16.12	32.35	36.48	10 00	8.00	12 24	812	19 64	20.40	19.28	20.80	7.25	2.875	7 00	.750 x .375	4	19.12	6.62	850	1120
404TS	19 40	16.12	29 35	33.48	10.00	8.00	12 24	812	19 64	20 40	19 28	20 80	4 25	2.125	4 00	500 x 250	4	19 12	6 62	950	1120
405T	19 40	17 64	33.85	37.98	10 00	8.00	13.74	812	19 64	20 40	19 28	20 80	7.25	2 875	7 00	.750 x 375	4	19 12	6 62	950	1250
405TS	19 40	17 64	30 85	34 98	10 00	8 00	13 74	812	19 64	20 40	19 28	20 80	4 25	2 125	4 00	500 x 250	4	19 12	6 62	950	1250
444T	21.80	17.50	37.50	42.25	11 00	9 00	14 50	812	21 90	22 90	21 80	23.80	8.50	3 375	8.25	875 x 437	4	21 12	7 50	1190	1760
444TS	21.80	17 50	33.75	38.50	11 00	9 00	14 50	812	21 90	22 90	21 80	23 80	4 75	2.375	4 50	625 x 312	4	21 12	7 50	1190	1760
445T	21.80	19 50	39 50	44.25	11 00	9 00	16 50	812	21 90	22 90	21 80	23 80	3.50	3 375	8.25	875 x 437	4	21 12	7.50	1400	2050
445TS	21 80	19 50	35 75	40 50	11 00	9 00	16 50	812	21 90	22 90	21 80	23 80	4 75	2 375	4 50	625 x 312	4	21 12	7 50	1400	2050
†447T	21.50	23.00	43.10	51.00	11.00	9 00	20 00	812	22 90	23 50	22 50	25 00	8.50	3 375	8.25	875 x 437	4	20 90	7 50	1500	2200
†447TS	21 50	23.00	39.35	47 25	11 00	9 00	20 00	812	22 90	23 50	22 50	25 00	4 75	2 375	4 75	625 x 312	4	20 90	7 50	1500	2200
†449T	21.00	28.50	48.10	-	11 00	9 00	25 00	812	22 90	-	22 50	-	8 50	3 375	8.25	875 x 437	4	20 90	7 50	1800	2500
†449TS	21 00	28 50	44 35	-	11 00	9 00	25 00	812	22 90	-	22.50	-	4 75	2.375	4 50	625 x 312	4	20 90	7 50	1800	2500

+ Tolerances:
Dimension D - 8.00 and less + .00 - .03; over 8.00 + .00 - .06
Dimension U - 1.500 and less, + .0000 - .0005; over 1.500, + .000 - .001

Conduit box will be mounted on opposite side upon request.

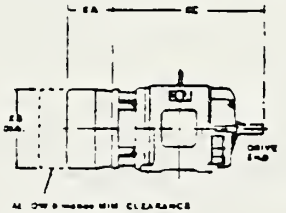
† For exact configuration of the R140T R180T and drip-proof 447-449 frames, see individual dimension prints.

These dimensions are not to be used for construction. Certified prints will be furnished upon request

BRAKE TORQUE LB. FT.	BRAKE DIMENSIONS (MAXIMUM) STANDARD ENCLOSED XA	STANDARD ENCLOSED XB	SEVERE DUTY XA	SEVERE DUTY XB	WATER-PROOF/ DUST-TIGHT XA1	WATER-PROOF/ DUST-TIGHT XB	EXPLOSION-PROOF XA	EXPLOSION-PROOF XB
1.5	4.25	6.59	5.00	6.88	5.00	6.88	[illegible]	4.00 *
3	5.68	6.88	5.68	6.88	5.68	6.88	5.68	6.00 *
6	4.69	8.59	7.75	9.38•	7.56	9.38•	8.15	8.00 *
10	5.75	9.00	7.75	9.38•	7.56	9.38•	8.12	[illegible]
15	7.31	9.38	7.75	9.38•	7.56	9.38•	9.12	[illegible]
25	7.31	9.38•	7.75	9.38•	7.31	9.38•	11.25	[illegible]
35	7.31	11.00•	7.62	11.00•	7.56	11.00•	13.38	[illegible]
50	8.69	11.00	9.00	11.00	8.94	11.00	13.38	[illegible]
70	8.12	11.00	8.12	11.00	8.12	11.00	-	-
75	8.75	11.00	9.00	11.00	8.94	11.00	13.38	3.75
105	9.19	11.00	9.62	11.00	9.44	11.00	13.38	3.75
125	12.12	16.00	11.48	16.00•	11.25	16.00•	-	-
175	13.76	16.00	12.44	16.00•	12.44	16.00•	-	-
280	13.38	16.00•	13.19	16.00•	13.19	16.00•	-	-
340	14.12	16.00	13.19	16.00	13.25	16.00	-	-
440	14.44	15.75	14.44	15.75	14.50	15.75	-	-
550	13.44	15.75	14.44	15.75	14.50	15.75	-	-

Standard enclosed, severe duty and water proof/dust tight brakes may be used with drip-proof and standard enclosed fan cooled motors, explosion-proof brakes may be used only with explosion-proof motors.

These dimensions are not to be used for construction. Certified prints will be furnished upon request.



ALLOW 6 inches MIN. CLEARANCE FOR BRAKE COVER REMOVAL

• When this size brake is used on motor frame shown below, stack up motor 1/2 inch

Standard, Severe Duty, Water proof/Dust tight – Frame 182T, 184T
Explosion proof – Frame 213T, 215T

• When this size brake is used on motor frame shown below, stack up motor 1 inch:

Standard, Severe Duty, Water proof/Dust tight – Frame 284T, 286T
Explosion proof – Frame 143T, 145T, 182T, 184T

FRAME SIZE	XC DRIP PROOF	XC TEFX TEXP
143T	11 37	12 91
145T	12 37	13 91
182T	13 62	16 32
184T	14 62	17 32
213T	16 68	19 20
215T	18 38	20 70
254T	21 50	24 22
256T	23 25	25 97
284T	23 87	25 66
284TS	22 50	26 99
286T	25 37	28 96
286TS	24 00	27 59
324T	26 30	30 38
324TS	25 00	29 08
326T	28 00	32 08
326TS	26 50	30 58
364T	29 13	34 40
364TS	27 90	31 85
365T	30 13	35 00
365TS	28 00	32 47
404T	32 29	37 71
404TS	29 99	34 73
405T	34 49	39 23
405TS	31 49	36 23
444T	36 25	43 62
444TS	34 50	39 87
445T	40 25	45 62
445TS	37 50	42 87

HP	Full Load RPM	Frame Size	Amperes 460V Locked	Amperes 460V Full Load	Code Ltr.	Starter Size Voltage 230	Starter Size Voltage 460	Efficiency % Load 1/4	Efficiency % Load 2/4	Efficiency % Load 3/4	Efficiency % Load 4/4	Efficiency % Load 5/4	Power Factor % Load 1/4	Power Factor % Load 2/4	Power Factor % Load 3/4	Power Factor % Load 4/4	Power Factor % Load 5/4	Torque % of Full Load Locked	Torque % of Full Load Min.	Torque % of Full Load Break down
50	3550	324T	455	67.0	G	4	3	80.9	87.6	89.1	89.0	88.2	37.8	59.6	73.4	78.5	82.1	190	185	255
	1770	326T	352	63.0	G	4	3	85.6	90.5	91.3	90.9	89.9	46.5	68.2	78.9	81.8	84.5	150	125	240
	1185	365T	348	72.0	F	4	3	82.9	88.8	90.1	90.0	89.1	32.1	52.6	67.0	72.4	76.9	141	141	229
	885	404T	400	70.0	F	5	3	86.3	90.7	91.3	90.8	89.6	34.2	55.3	68.9	73.4	77.0	120	151	242
60	3550	326T	404	76.0	F	5	4	83.6	89.3	90.4	90.2	89.3	43.2	65.4	77.6	81.8	84.6	140	100	240
	1770	364T	425	76.5	G	5	4	85.5	90.4	91.2	90.8	89.8	46.0	67.6	78.3	80.9	82.5	157	134	214
	1180	404T	378	74.5	F	5	4	87.0	91.0	91.4	90.7	89.4	48.0	70.0	80.3	83.0	84.6	148	137	216
	885	405T	417	84.0	F	5	4	86.0	91.1	91.7	91.1	90.0	34.4	55.6	69.1	73.6	77.0	155	113	219
75	3540	364T	450	93.5	E	5	4	83.8	89.2	90.1	89.7	88.6	48.2	70.1	80.7	83.8	85.6	123	120	222
	1770	365T	531	96.0	G	5	4	86.1	90.8	91.6	91.3	90.3	44.6	66.3	77.3	80.1	81.8	164	132	211
	1180	405T	520	93.0	F	5	4	87.6	91.5	92.0	91.4	90.3	47.0	69.2	79.7	82.7	84.5	170	138	228
	885	444T	467	100.0	E	5	4	86.8	91.2	91.8	91.3	90.3	39.2	60.8	73.2	76.9	79.5	130	110	220
100	3550	365T	675	120	F	5	4	86.1	90.8	91.7	91.4	90.5	50.5	72.3	82.2	85.0	86.7	139	137	215
	1775	404T	690	121	F	5	4	87.1	91.5	92.3	92.0	91.2	50.4	71.9	81.6	84.1	85.7	159	130	227
	1180	444T	588	121	E	5	4	88.0	91.7	92.0	91.3	90.0	55.5	75.9	83.9	86.1	85.7	132	102	208
	885	445T	680	145	F	5	4	86.4	91.1	91.9	91.6	90.7	36.9	58.4	71.1	75.5	78.7	143	112	219
125	3555	404T	814	149	F	-	5	85.6	90.6	91.7	91.5	90.8	53.9	74.7	84.6	86.9	87.2	137	129	257
	1775	405T	870	146	F	-	5	88.3	92.2	92.8	92.5	91.7	53.9	74.7	84.1	86.5	86.7	161	128	227
	1185	445T	825	155	F	-	5	86.6	91.2	92.0	91.8	90.9	45.9	68.0	78.9	82.2	84.1	148	148	241
150	3555	405T	955	171	F	-	5	88.0	91.9	92.5	92.1	91.2	65.0	82.4	88.4	89.2	89.4	135	126	242
	1775	444T	1050	192	F	-	5	86.0	90.9	91.9	91.7	90.9	42.7	64.6	76.3	79.7	82.0	165	151	255
	1180	445T	921	182	F	-	5	87.8	91.9	92.5	92.1	91.2	50.1	71.8	81.4	84.9	85.4	131	117	225
	885	447T	1070	180	C	-	5	-	92.0	92.5	92.5	-	-	71.5	80.3	83.5	-	163	120	215
200	3560	444T	1149	228	F	-	5	87.3	91.5	92.3	91.9	91.1	62.7	81.2	87.0	89.2	89.8	143	120	270
	1775	445T	1294	215	F	-	5	89.5	92.9	93.3	92.9	91.9	57.8	77.4	84.2	85.7	86.0	157	131	213
	1185	447T	1370	215	F	-	5	-	92.5	93.5	93.5	-	-	72.0	79.0	81.0	-	150	110	210
	880	449T	1300	210	F	-	5	-	91.0	94.5	94.0	-	-	68.5	77.5	80.0	-	135	124	205
250	3560	445T	1651	279	F	-	6	89.0	92.5	92.9	92.4	91.5	69.4	85.3	90.1	90.8	90.8	141	115	209
	1775	445T	1711	296	F	-	6	89.8	93.1	93.5	93.1	92.2	54.9	75.4	84.1	84.9	85.5	175	125	215
	1180	447T	1589	298	F	-	6	-	93.0	94.0	93.0	-	-	70.4	80.0	81.0	-	120	95	210
	885	449T	1560	301	F	-	6	-	93.5	93.0	92.0	-	-	77.0	83.0	84.5	-	120	85	205
300	3560	445T	2150	334	G	-	6	89.6	92.9	93.3	92.8	91.9	67.6	84.4	89.0	90.7	90.9	150	100	220
	1775	445T	3093	367	F	-	6	89.0	92.6	93.2	92.0	91.9	48.0	69.9	80.0	82.5	81.0	160	100	200
	1185	449T	1800	355	F	-	6	-	95.0	95.0	91.5	-	-	79.0	84.5	84.0	-	120	110	215
350	3560	445T	2475	390	F	-	6	89.2	92.7	93.2	92.7	91.9	60.7	80.2	87.1	88.8	89.7	110	100	250
	1775	447T	2010	398	F	-	6	-	94.5	95.0	~~94.5~~ 94.0	~~91.9~~ 92.7	-	81.0	86.0	85.0	-	135	115	210
	1185	449T	2250	390	F	-	6	-	91.5	91.5	92.5	-	-	80.5	87.0	89.5	-	120	100	240
400	3560	447T	2600	435	F	-	6	-	94.5	95.0	94.5	-	-	85.0	89.5	91.0	-	140	140	260
	1785	449T	2724	471	F	-	6	-	95.0	95.5	~~93.7~~ 92.7	-	-	78.0	83.0	85.5	-	170	130	230
450	3560	449T	3050	465	F	-	7	-	94.5	94.5	94.0	-	-	88.0	91.5	92.5	-	150	120	260
	1775	449T	2760	488	F	-	7	-	95.4	95.2	~~94.1~~ 93.5	-	-	82.5	90.7	91.3	-	160	100	260
500	3555	449T	3250	519	F	-	7	-	94.5	94.5	94.0	-	-	88.0	91.5	92.5	-	145	130	220

TYPICAL DATA NOT TO BE GUARANTEED

1/2 .137 3/4 47 Full 93.6

ENERGY EQUIPMENT CO.
P.O. Box 10567
Bainbridge Island, WA 98110
(206) 842-7338

TYPICAL PERFORMANCE DATA
DRIP PROOF PACEMAKER MOTORS

Item 3

ITEM 4

TransElectro
A SUBSIDIARY OF GULL INDUSTRIES CORPORATION

July 1, 1982

Mr. Don Liupakka
Energy Equipment Co.
P.O. Box 10667
Bainbridge Island, WA 98110

Re: Paragon Engineering Job
60KW, 480V

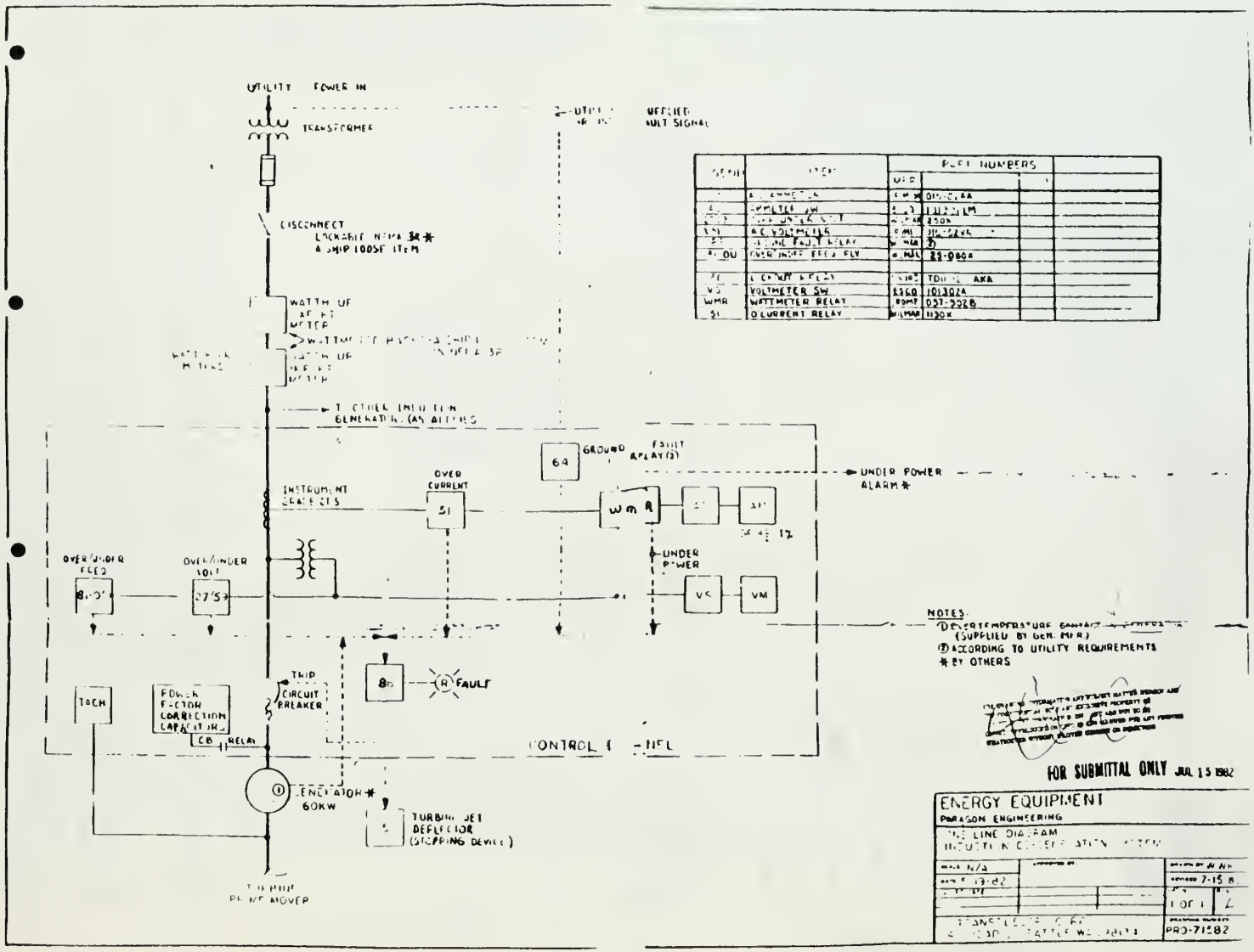
Dear Don:

TransElectro requotes the following panel for your job; it will be a wall mount enclosure, approximately 42" x 60" x 12", containing the following components:

2-Wattmeter Bases, Import & Export		G.E.
Volt Switch	Series 101	Esco
Voltmeter	4½" 2%	Crompton
Ammeter	4½" 2%	Crompton
Amp Switch	Series 101	Esco
86 Lockout Relay		Omron
Over/Under Voltage Relay	(27/59 Device)	Wilmar
Over/Under Frequency Relay	(81 Device)	Wilmar
Watt Meter Relay & Transducer	2 Set Point	Crompton
Current Transformers		Crompton
Potential Transformers		Crompton
Capacitor		G.E.
Overcurrent Relays	(51 Device)	Wilmar
Ground Relay	(50 Device)	Wilmar
Capacitor Contactor		ASEA
Main Contactor		ASEA

It will also contain all fuses, terminal boards and necessary wire, in addition to a one-line drawing, a bill of materials and a maximum of ½ day for coordination.

The above quotation and selection of components are based upon discussions between yourself, Paragon and our engineers to minimize costs. This system is designed to provide the minimum of protection and does not meet the original specifications, nor does it take into account any unusual site or utility conditions. TransElectro is not verifying the acceptance by the utility; therefore, this quotation is subject to final review after utility approval and/or comments.

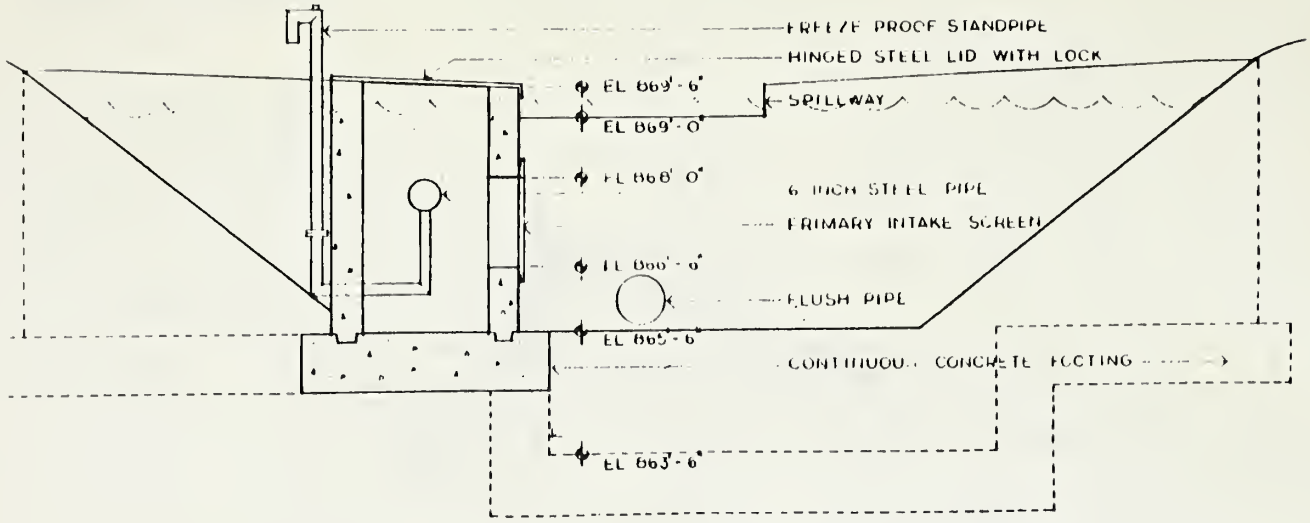

UTILITY POWER IN
TRANSFORMER
DISCONNECT
LOCKABLE NEMA 3R *
A SHIP LOOSE ITEM
WATTHOUR METER
WATTMETER
INSTRUMENT CIRCUITS
OVER CURRENT
51
64
GROUND FAULT RELAY (2)
UNDER POWER ALARM *
wm
UNDER POWER
VS
VM
OVER/UNDER FREQ
OVER/UNDER VOLT
27/59
TACH
POWER FACTOR CORRECTION CAPACITORS
CB
RELAY
TRIP CIRCUIT BREAKER
86
FAULT
CONTROL PANEL
GENERATOR *
60KW
TURBINE JET DEFLECTOR (STOPPING DEVICE)
PRIME MOVER
NOTES:
(1) ACCORDING TO UTILITY REQUIREMENTS
* BY OTHERS
FOR SUBMITTAL ONLY JUL 15 1982
ENERGY EQUIPMENT
PARAGON ENGINEERING
PRD-71582

II. Construction

A. Final Design

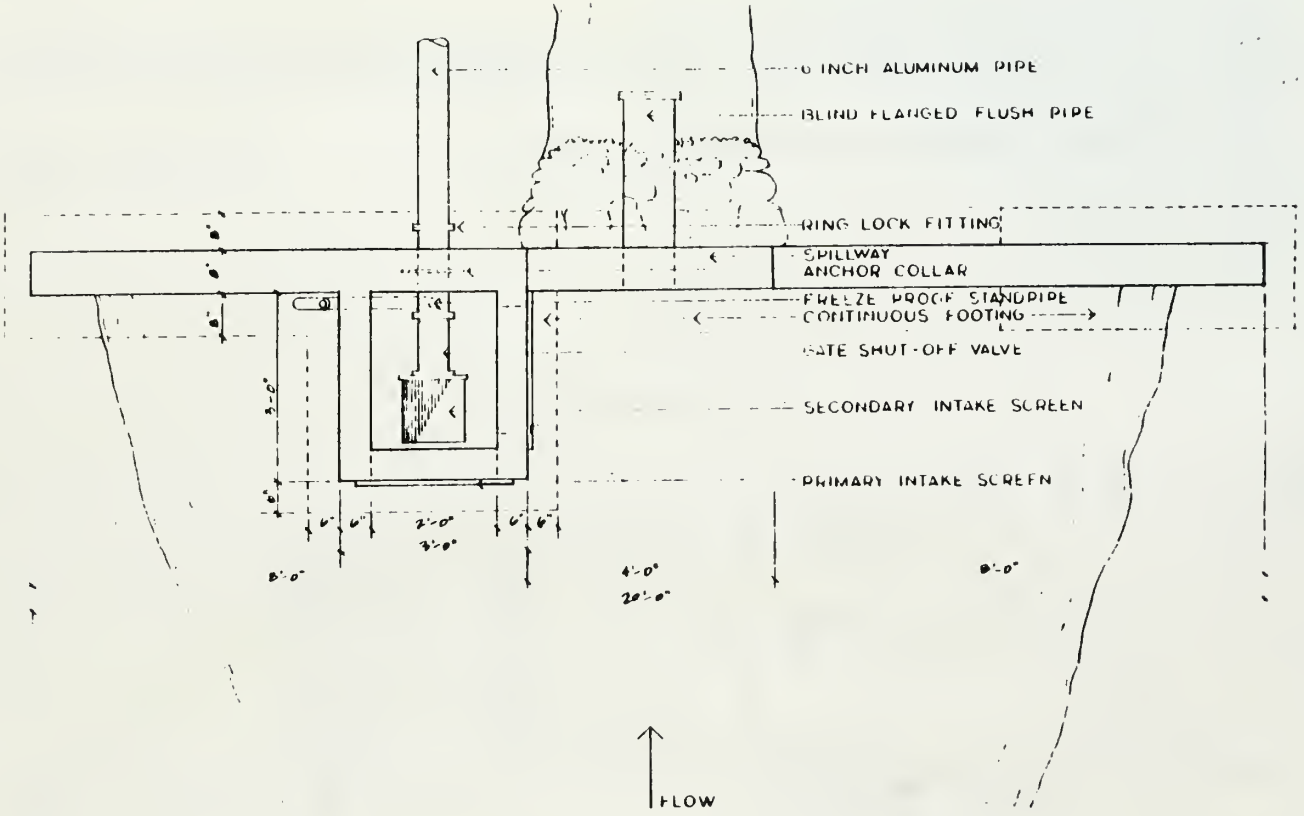
DIVERSION STRUCTURE

The diversion structure is a reinforced concrete wall with a spillway to pass flood stage water. Water enters the small pond and settles out any particulate which will be flushed periodically. Excess water passes over the spillway and back into the original stream bed. Intake water passes through either of the two primary screens on the concrete intake box which has a locked metal roof. Water then continues through a secondary screen on the pipe end, through an intake shut-off valve, past the freeze proof air vent standpipe and into the overground aluminum piping.



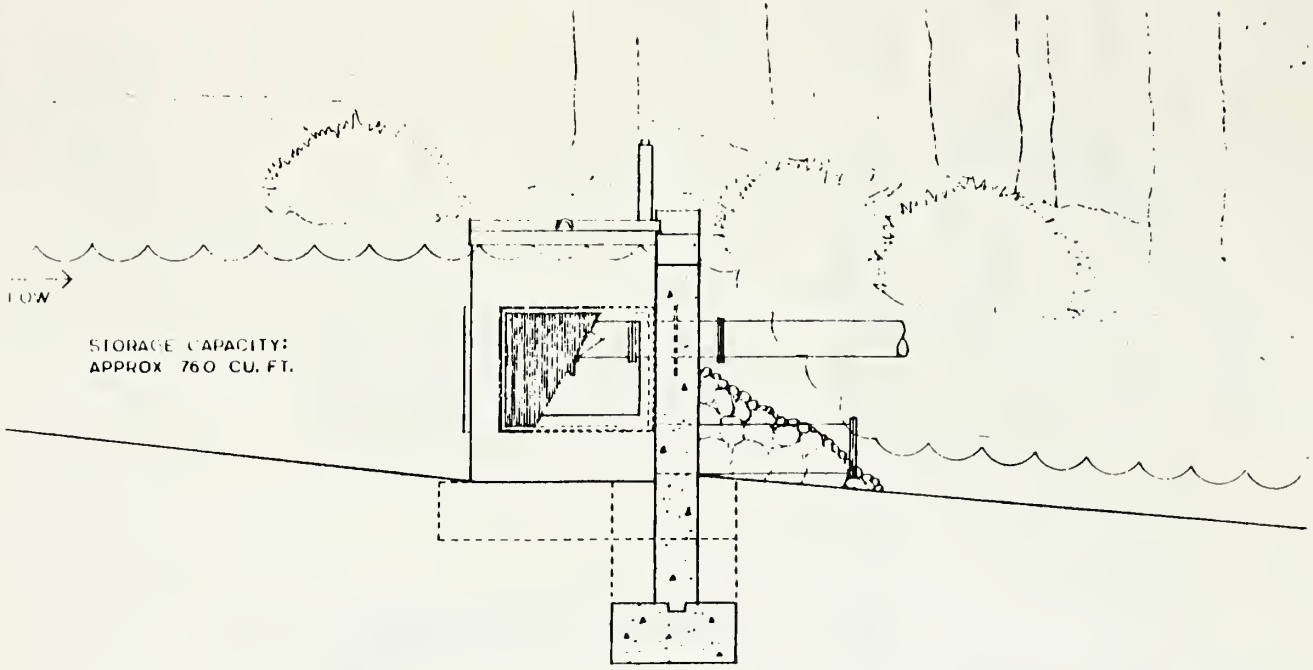
INTAKE STRUCTURE — ELEVATION LOOKING DOWNSTREAM — SCALE 1/2" = 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT | DNRC GRANT 654-810



INTAKE STRUCTURE PLAN SCALE 1/2" = 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT | DNRC GRANT 654-810

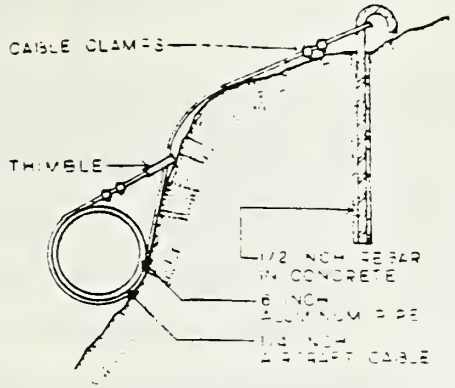


INTAKE STRUCTURE SECTION THRU SPILLWAY SCALE 1/2" = 1'-0"

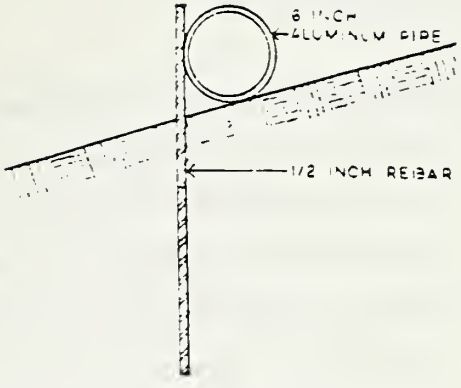
CASCADE CREEK MICRO-HYDRO PLANT | DNRC GRANT 654-810

ALUMINUM PIPING

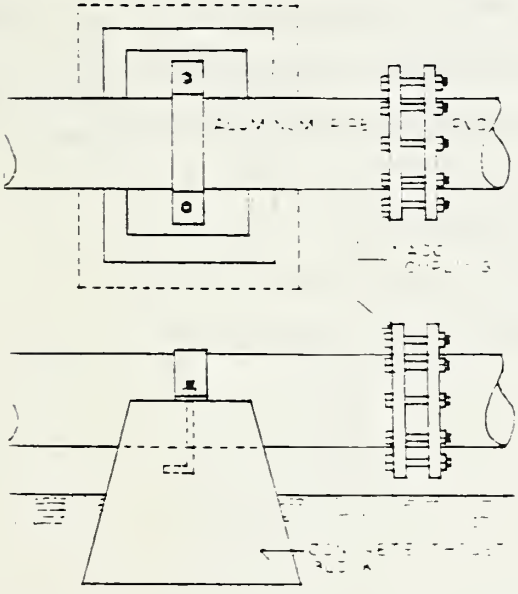
The overground ringlock 6 inch diameter aluminum piping is coupled to the steel intake piping of the diversion structure with a standard ringlock coupling. It then wraps around a steep and rocky side hill where it is cable supported every 6 linear feet. Once onto less steep terrain, it is stake supported until it terminates at a concrete pipe cradle where it couples to the underground pvc piping. Total length is 220 feet.



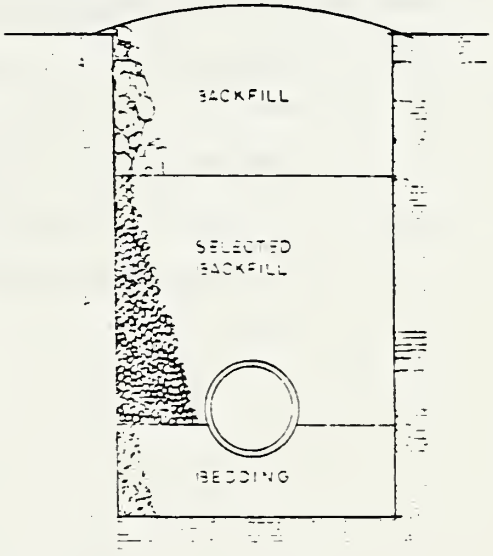
PIPE INSTALLATION AT CLIFF



PIPE INSTALLATION ON GRADE



ALUMINUM / PVC JUNCTION



BURIED PIPE INSTALLATION

[illegible]	PIPE DETAILS

POLYMER PIPING

The 6 inch diameter polymer piping connects to the aluminum piping at the concrete cradle with a Naco slip by slip, fusion coated coupling. Starting with 125 psi ips pvc, the piping graduates to 160 psi ips pvc, then to 200 psi ips pvc, then to 250 psi permastran, and finally to 350 psi permastran which connects to the steel piping of the power house with a Naco slip by weld on fusion coated coupling. The total installation will be per ASAE standard S376. Installation will move downhill from the top and sections of line will be pressure tested to allow the trench to be backfilled as installation proceeds.

STEEL PIPING

The piping inside the power house consists of 6 inch schedule 40 steel with the following:

1) A flange to bolt to the permastran coupling.
2) An anchor to bolt and pin to a capped 6 inch I beam which is embedded in concrete to take maximum thrust forces.
3) A 3/4 inch half coupling and piping for a valved, 0-600 psi, 3½ inch face, pressure meter.
4) A flow meter tap for a DNRC specified valved flow meter and piping.
5) A 2 inch valved bypass and flush pipe with a blind flanged tee for a future ranch fire hose fitting.
6) A 6 inch steel shut off gate valve which is bolted to the flange of the turbine needle nozzle.

POWER HOUSE EQUIPMENT

MECHANICAL AND HYDRAULIC EQUIPMENT

The turbine assembly is bolted into a recess in the power house slab. The needle nozzle of the turbine assembly is flange bolted to the steel piping which is in a drainable pit below diamond plate. A handwheel with a fine pitch threaded shaft operates a hydraulic cylinder which is slaved to another hydraulic cylinder mounted on the needle shaft. This regulates jet size and water flow to the turbine. Water strikes the turbine, falls into a concrete pit and exhausts through a 12 inch diameter 30 foot culvert back into Cascade Creek. The exhaust end of the culvert has a grating to prevent entrance of anything into the culvert and turbine housing.

The turbine is specifically designed for heads and flows found at this site and runs at 1800 RPM for direct coupling to the generator. Installation and servicing of the turbine, generator, and steel piping is accomplished using an overhead I beam.

Safety shutdown equipment consists of a jet deflector which is held away from the jet by a trip solenoid hooked to the main contactor. The deflector falls into place when the solenoid de-energizes upon contactor opening.

ELECTRICAL EQUIPMENT

The 75 KW, 3 phase, 460 volt, 1325 RPM induction machine is specifically designed as a generator. Generator wiring passes through concrete embedded EMT conduit to the switchgear which consists of metering, protection, and power factor correction equipment agreed upon by Park Electric Coop, Trans Electro (the supplier) and Tom Budde. Import and export watt metering can be placed either inside or outside the power house. An outdoor lockable disconnect switch connects the switchgear to Park Electric Coop's outdoor transformers located at the power house. Generator start up is manual.

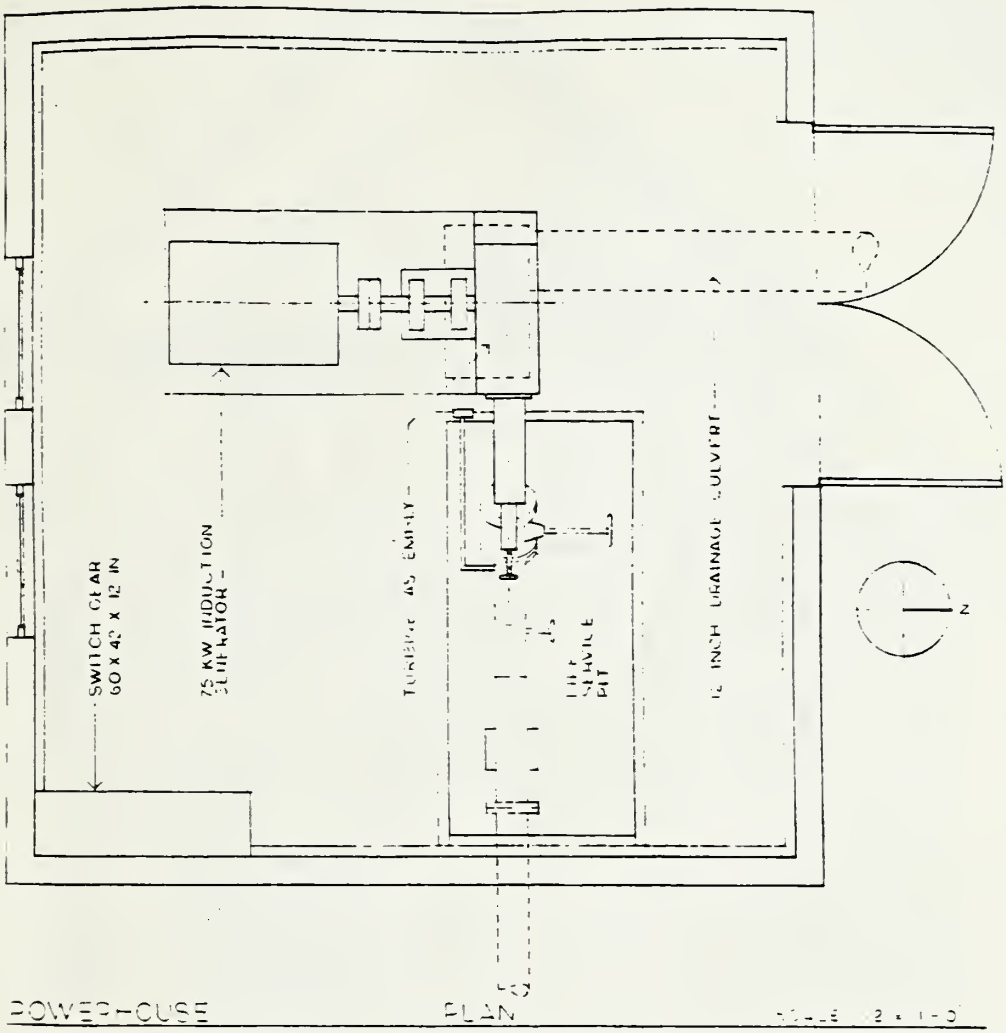
NOTE: Future automation requires 6300 feet of underground control wire which will be connected to a pressure transducer at the intake structure to monitor available water. Installation of a microprocessor control will maximize plant output by regulating the needle nozzle for maximum water use and by performing other functions such as automatic start up and data logging.

POWERHOUSE STRUCTURE

The powerhouse design is patterned after the existing ranch house. It utilizes standard 2 x 4 construction over 6 inch reinforced concrete foundation walls. The exterior finish materials include clapboards, shingles, corner boards, and trim materials to match the ranch house. The interior materials are ½ inch drywall and fir trim. The power house will be insulated and two site built south-facing windows will provide both day-lighting and minimal solar heat contribution. Electrical equipment will be as follows: A breaker box, an internal light fixture, an external light fixture, a switch to operate both lights, and an outlet receptacle.

Special equipment includes the following: Double 3'-0" x 6'-8" metal doors for easy access to the turbine; an overhead 6 inch wide flange beam for positioning and servicing the steel piping and turbine equipment; a flush diamond plate cover to easily maintain the steel piping and valves; and two gable vents to help dehumidify the plant.

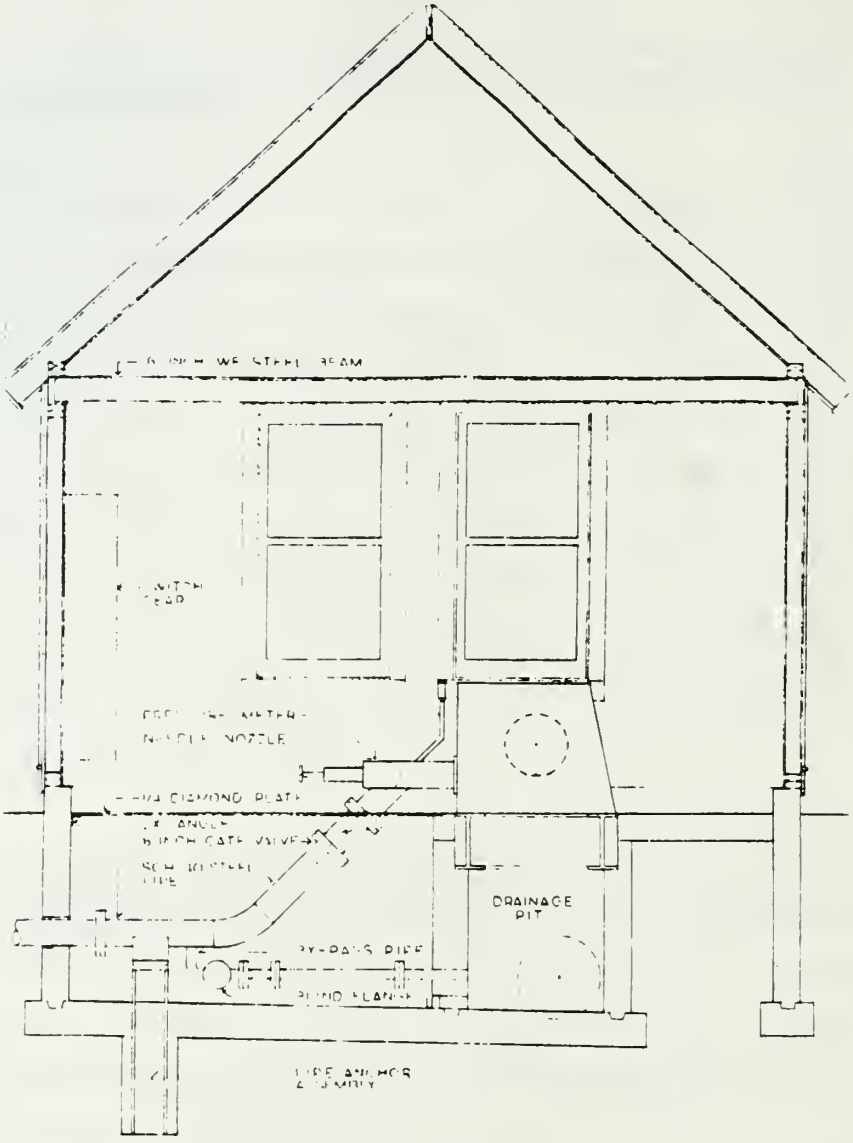
Special construction is necessary in the concrete work. All the reinforcing bars must be welded to form a continuous mesh structure and then attached to a ground rod. This system of construction will prevent any false ground fault conditions.



POWER-HOUSE PLAN SCALE 1/2 = 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT

[illegible] BUDDE [illegible]



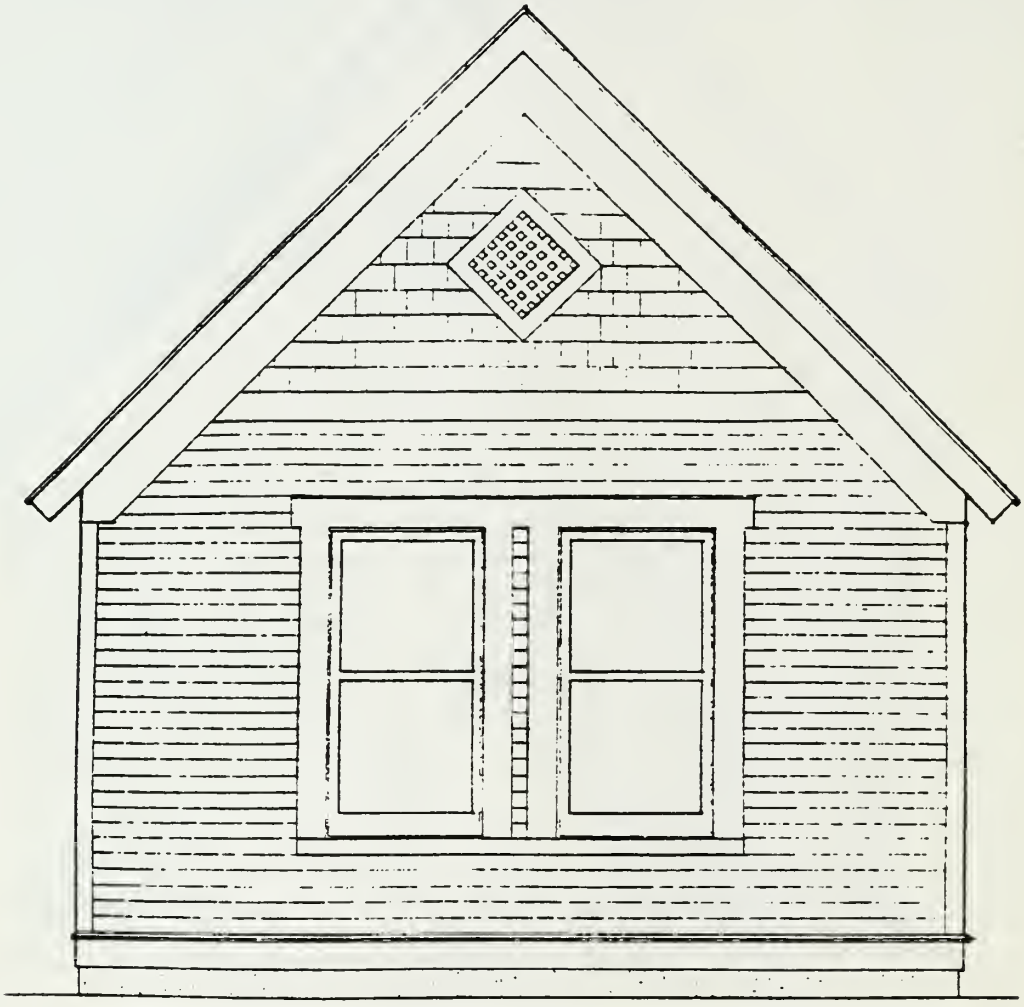
POWERHOUSE SECTION SCALE 1/2 - 1-0

CASCADE CREEK MICRO-HYDRO PLANT

THOMAS AND JODY BUDDE | M RANCH

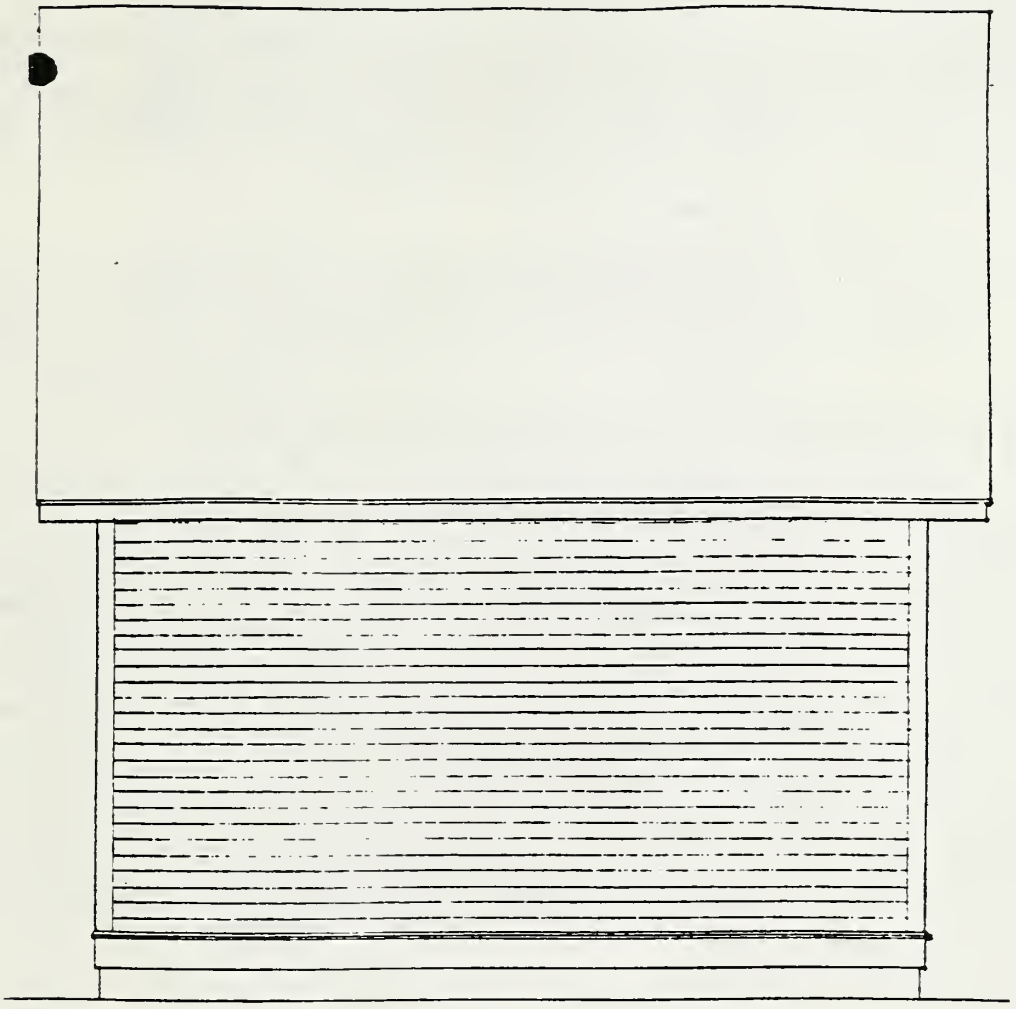
POWERHOUSE NORTH ELEVATION SCALE 1/2" = 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT



POWERHOUSE SOUTH ELEVATION SCALE 1/2" = 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT



POWERHOUSE EAST WEST ELEVATIONS SCALE 1/2"- 1'-0"

CASCADE CREEK MICRO-HYDRO PLANT

[illegible] ROAD [illegible]

B. Actual Installation of the Project

1. Diversion

Project installation began at the diversion structure and proceeded downhill to the powerhouse. Diversion structure was excavated with a small crawler and by hand. Concrete was hand mixed and poured into hand-made forms. This was difficult and time consuming, but satisfying and well done.

2. Pipeline

The aluminum piping leading from the diversion structure around a cliff area to the buried PVC pipe required pedestal supports with concrete pads. Steel piping would have been better - it would support itself and be more durable - but (1) would have been much heavier to get to the job site and (2) it would have been very difficult to get a portable welder close enough.

The polymer piping arrived late in the fall and so its installation was slowed by bad weather. It was buried approximately four feet. The steepness of the upper 2,000 feet section of pipeline was not judged properly by heavy equipment operators doing the trench work. So this section was dug and backfilled by hand. This hand work was much cleaner and caused much less impact on the land. The remainder of the trench was dug with a backhoe. Bedding material had to be hauled since the ground had so many large rocks. Backfilling was done with a loader and a cat. Heavy supervision was required during trenching, pipe laying and backfilling to insure proper installation. As the pipeline was installed from top to bottom, it was periodically filled and pressure tested so the backfilling could be completed. It is very important to have enough cover material over the pipeline while testing so that it does not move, come apart, and wash out the trench downhill.

3. Powerhouse

The powerhouse was designed to efficiently and comfortably house all equipment and be compatible with existing ranch buildings. It was built as shown in the drawings. The concrete work was probably the most time consuming, but was straightforward. One of the vents was eliminated for quietness outside the powerhouse. This necessitated putting in a lower vent on the opposite wall to achieve good cooling and ventilation.

4. Turbine/Generator Installation

The turbine/generator set came on a steel frame/palate. It was wenched off of a trailer into the powerhouse and

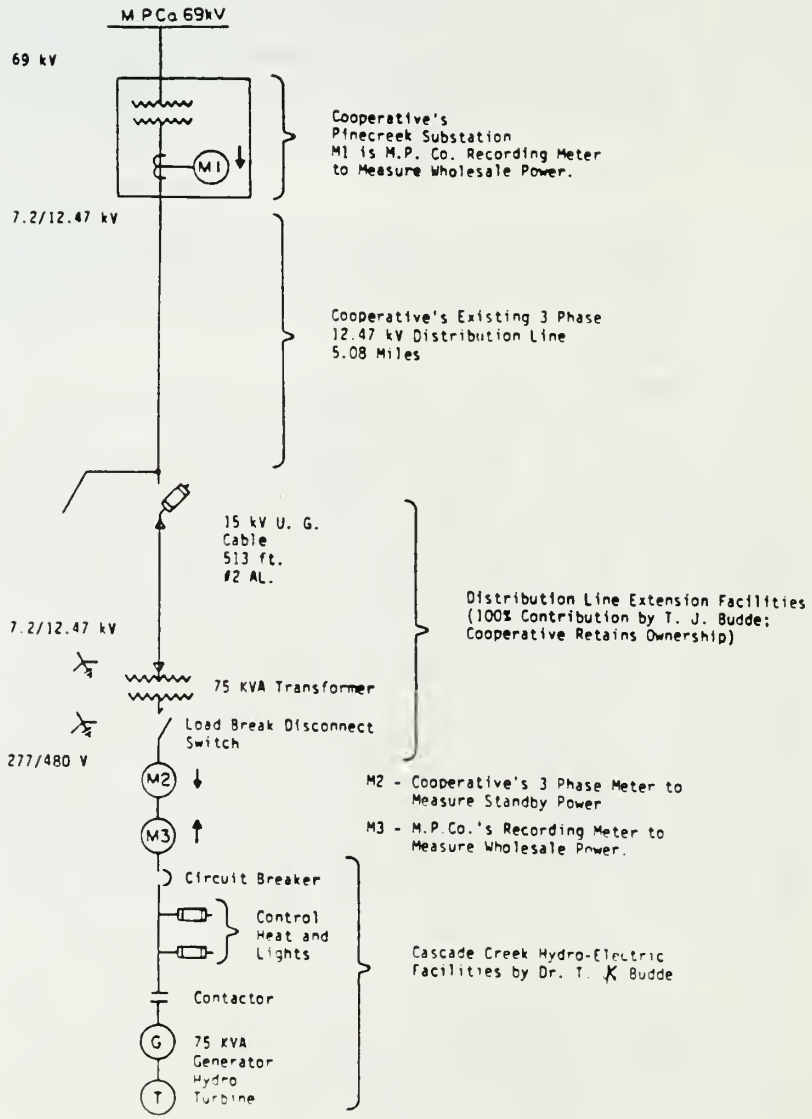
set in place using the overhead beam. Its frame was then leveled, grouted and anchor bolted to the concrete floor. The turbine generator shafts came aligned, but were checked again before start up. An electrician wired the generator in the same manner any motor is wired.

5. Interface Equipment - See Schematics

The switchgear came in a standard Hoffman box which was bolted to the wall of the powerhouse. It was simply wired to the generator and to the utility metering.

III. Utility Interface

The utility interface requirements, other than switchgear, are shown in the attached one-line drawing. They include import and export metering, lockable disconnect switch and transformers. The meters and disconnect are located on the outside wall of the powerhouse next to the pad mount transformer bank. A buried line connects the power line at the highway with the transformer bank. The installed cost of the buried line, transformers, and meters was about $12,000.00. The Montana Power Company also installed a meter at their Pine Creek substation to monitor if power is ever fed back into their 69 KV lines. This cost about $800.00. After all equipment was installed and the utility was notified that it was per previously discussed approved drawings and specs, start up was okayed. Before start up, the whole system was rechecked and then the generator was run as a motor with turbine uncoupled to check for proper rotation direction and any other problems. All was okay, so turbine and generator were coupled, and again the generator was motored for a few minutes to check for any vibrational or bearing problems. Still okay, water was turned on to the turbine, power was generated for a short time, and again the whole system was rechecked. Then it was restarted and watched closely for the next two days. No dummy load test was possible because of the induction generator's inability to self-excite. Various small but aggravating leaks (from weld pinholes, etc.) on the turbine housing were attended to during any shutdowns with silicone compound. An O ring was fitted to the turbine door to stop leaks. Also, a slow blow fuse in the switchgear was too small and had to be replaced with a larger fuse.


M P Co 69kV
69 kV
M1
Cooperative's
Pinecreek Substation
M1 is M.P. Co. Recording Meter
to Measure Wholesale Power.
7.2/12.47 kV
Cooperative's Existing 3 Phase
12.47 kV Distribution Line
5.08 Miles
15 kV U. G.
Cable
513 ft.
#2 AL.
Distribution Line Extension Facilities
(100% Contribution by T. J. Budde;
Cooperative Retains Ownership)
7.2/12.47 kV
75 KVA Transformer
Load Break Disconnect
Switch
277/480 V
M2
M2 - Cooperative's 3 Phase Meter to
Measure Standby Power
M3
M3 - M.P.Co.'s Recording Meter to
Measure Wholesale Power.
Circuit Breaker
Control
Heat and
Lights
Cascade Creek Hydro-Electric
Facilities by Dr. T. K Budde
Contactor
G
75 KVA
Generator
Hydro
Turbine
T

IV. Demonstration

A. Purpose and Benefit

Theory, as well as equipment used in hydroelectric installations, are well documented and proven on all scales. It is only recently, with rising energy costs and clean energy requirements that it has become essential to look at all scales and phases of water power. This project is an answer to what is becoming a necessity. The installation and operation of an extremely well-designed small hydropower plant tied into the utility grid serves to do the following:

1. Demonstrate the suitability of small hydropower for individual and statewide energy needs;

2. Synchronize with and build upon the Public Service Commission's guidelines for power sales from small users to utilities;

3. Provide data regarding system cost, performance, reliability, safety and environmental compatability;

4. Provide to the public, in concrete form, engineering design, environmental knowledge, solutions to design and installation problems, and state of the art technology, all of which will be available for future installations;

5. Break the trail for future installations for small producers by demonstrating the process, economy and feasibility to both utilities and people of Montana;

6. Provide maximum kilowatts at high water runoff during the peak summer demand; and

7. Maintain voltage stability in the main power line by minimizing line losses.

B. Public Access Schedule and Site Visitation

At the time of this writing, a formal public access schedule has not yet been determined. Please contact Dr. Thomas K. Budde or the Montana DNRC to arrange a visit.

FINAL REPORT

Grant Agreement #654-810
Prepared by Roger Kirk, Paragon Engineering
7/15/83

ACTUAL PROGRESS OF THE PROJECT

1) Power Sales Contract: The long term standard tariff contract has been signed with the Montana Power Company. They have not been willing to enter into an acceptable long-term contract which guarantees any price for power.

2) Aluminum piping: Supports are complete.

3) Steel piping: Complete.

4) Powerhouse equipment: Complete.

5) Powerhouse structure: Dry wall is ready for taping and painting.

COMMENTS

The whole powerhouse equipment installation was completely smooth, but there are lots of opportunities for difficulty and danger if one is not prepared or makes design or construction errors. Alignment of components is critical.

INVOLVEMENT WITH THE DEPARTMENT

Have been in contact with Dave Dysinger a few times to clarify dimensions and delivery time of the flow meter.

PUBLICITY

Two articles have appeared since the last report--one in the Livingston Enterprise and one in the Billings Gazette.

EXPENDITURES

The Paragon engineering invoice dated 7/15/83 is a complete listing of expenditures since the last report, except for

Expenditures, cont.

$600.00 more powerhouse labor by Dr. Budde for a total of $1,200.00, and $4,330.50 total interest on the construction loan to 7/14/83.

REA and MPC interconnect costs were not included in the original budget, as power was going to be sold to the REA and they were going to assume these costs.

RECOMMENDATIONS

Before plant start-up, go through all mechanical equipment and electrical circuitry to make sure that everything is operating correctly and that connections are correct and secure. There is a lot of opportunity for damage to equipment and personnel, so standard safety practices must be followed.

GENERAL DESCRIPTION

This 67 KW capacity hydroelectric installation was designed and installed totally by Paragon Engineering--Susan Young, Project Coordinator and Roger Kirk, Project Engineer. It feeds directly into the Park Electric Coop power grid. The project is located totally within private land owned by Tom Budde. The system water intake, 860 feet above the power house on Cascade Creek, is a concrete structure with trash screening, shut off valve, and an air escape and vacuum inlet for the pipeline. The 6 inch pipeline is over ground aluminum for a short distance at the top, then buried PVC graduating in pressure rating to fiberglass reinforced PVC and then to

General Description, cont.

steel inside the power house. Total Pipe length is 6180 feet.

The steel piping (including a gate shut off valve and a gate bypass valve) at the power house terminates at the hand operated needle nozzle of the pelton turbine assembly. The needle nozzle will be adjusted throughout the year to follow available stream flow. Plant output based on stream flow, power at the jet, and turbine and generator efficiencies is 67 KW and at least a 60% capacity factor. A culvert discharges exhaust water back to Cascade Creek.

The horizontal shaft, overhung turbine assembly is directly coupled to the 75 KW induction generator. Runaway and shutdown automatic protection is provided by a jet deflector solenoid actuated by an open condition of the main contactor. The generator is interfaced to the grid transformer with switchgear, capacitive power factor correction, metering, and a lockable disconnect switch.

FINAL BUDGET

Category	DNRC	Other	Total
Salaries & Benefits	--	1,200.00	1,200.00
Operating Expenses			
a) Contracted Services	11,492.30	29,529.12	41,021.42
b) Supplies	22.60	--	22.60
c) Communications	209.00	650.00	859.00
d) Travel	366.25	1,666.50	2,032.75
e) Construction loan interest	--	4,330.50	4,330.50
Equipment	32,845.85	27,898.72	60,744.57
Administrative	64.00	--	64.00
TOTAL	$45,000.00	65,274.84	$110,274.84

ENERGY/PERFORMANCE

The project was expected to put out 65 KW maximum. It is now running at 67 KW. When first brought on line, output was about 60 KW, but some fine tuning on the turbine, and also of the nozzle settings, brought this up to 67 KW where it has been running constantly. Except for the first month of the fine tuning and adjustment, it has been running flawlessly and the grid has been stable enough not to knock it off line, except for a few times during power outages. The Small Hydroelectric Systems and Equipment turbine is built to last, and is efficient in this application.

Intake trash screens required cleaning about once every day or two during high water, but now require it less than once a week.

PAYBACK

Assuming the net revenue is 80% of gross, and that gross is $25,000.00 per year, then simple return on investment is .8 X $25,000.00 divided by the total cost, or about 18%.

JOBS

Paragon Engineering, the firm that did the design and installation of this plant, now has other similar jobs in process. Operation and maintenance of this plant takes time and can be considered a part-time job.

FINAL ASSESSMENT

This high head plant is an excellent performer, both physically and economically. Anyone that visits this site can see how clean it is--there is virtually no adverse environmental impact. This project, hopefully, is the forerunner of many more small hydro plants--the total contribution of which will be very significant to Montana in terms of the environment, economy, and dependability of electrical energy.

Small hydro can defer, if not eliminate, the need for future coal-fired steam generation plants and nuclear plants and their devastating, unhealthy, and uneconomical environmental effects.

Decentralized power generation is inherently much more economical, efficient, reliable, and of higher quality than centralized generation. The difficulty now is whether the Montana Power Company can be forced to obey law and give contracts to qualifying facilities that are stable in duration and price, and that offer true avoided costs for pricing. So far, MPC has avoided this by delaying and/or refusing to negotiate in good faith. The Montana Power Company tactic has been to tell everyone that they are protecting the rate-payer from having to pay a higher price to renewable energy source facilities. They omit telling everyone that the rate-payer will pay a higher dollar price for energy this January from Montana Power Company's Colstrip 3 and 4, and this does not include the price of environmental pollution and degradation.

Final Assessment, cont.

Because of the inability to secure a contract with MPC before construction, and because small hydro is an old technology only recently being reapplied, this project would not have been possible without the financial help received from the DNRC. Thank you. Montana's money was well spent.

In conclusion, this project is an example of a highly economical, reliable, clean, environmentally beautiful, and renewable source of energy which will contribute to, and help keep Montana, Montana for many many years.

PARAGON ENGINEERING
P.O. Box 1143
Bozeman, Montana 59715
7/15/83

Customer: Dr. Thomas K. Budde
M Ranch
P.O. Box 1326
Livingston, Montana 59047

MATERIALS, EQUIPMENT & SERVICES RENDERED:

Grant Category/Description		Total Cost	Amount Due
II A 6	Report Preparation	$ 25.00	$ 25.00
III A	System Equipment		
	Powerhouse Equipment	$10,014.00	$10,014.00
	Steel Piping	283.13	283.13
	Electrician & Materials	1,580.07	1,580.07
	MPC - Metering	3,065.00	3,065.00
	REA Hookup	7,620.20	7,620.20
	Concrete Form Rental	120.00	120.00
	Powerhouse Structure Material	1,464.00	1,464.00
	Powerhouse Miscellaneous	338.15	338.15
SYSTEM EQUIPMENT TOTAL		$24,484.55	$24,484.55
TOTALS		$24,509.55	$24.509.55

Please remit total amount to: Paragon Engineering
P.O. Box 1143
Bozeman, Montana 59715

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